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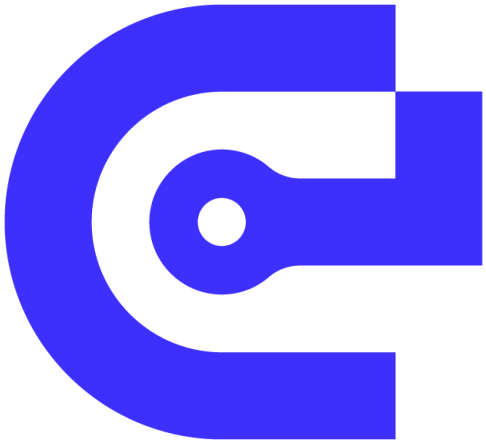


Cooperation and training on innovation and entrepreneurship in the eHealth community (CONNECT)

2020-1-RO01-KA203-080244

IO1 - eHealth Interdisciplinary Curriculum: mHealth

Partner: Babes-Bolyai University

Cluj-Napoca, October 31, 2021

Contents

1. Learning objectives of the mHealth module

[The objective of this section is to describe the module's brief statements that describe what students will be expected to learn by the end of the module. The learning objectives can reflect the educational standards used by your institution (if the case), or they can be drawn from international Common Core Standards. The learning objectives need to be closely connected with the lesson plans. Some examples of developing learning objectives can be found here]

[This part should not exceed a page]

Learning objectives of the module:

1. Understand the concept of mHealth and how it can strengthen the health systems.
2. Differentiate between different behavior change theories, models, and taxonomies.
3. Recall the elements of mHealth software management.
4. Apply the concepts learned in the model to design a potential mHealth app.

2. Foundational knowledge of the mHealth module

[The objective of this section is to briefly describe the foundational knowledge of the module. It refers to main concepts, theories, models, terminology, principles, and methods being currently used related to the module that are going to be further studied in the lesson plans]

[This part should ideally not exceed two pages. However, if needed, it can go up to four pages]

Definition of mHealth

The World Health Organization (WHO) defines mHealth as the use of mobile and wireless technologies to support the achievement of health objectives. Since mHealth is most suitably understood as a tool for strengthening health systems and promoting healthy behaviors, the word "support" in this definition is a key term (World Health Organization, 2011). mHealth is part of the larger field of eHealth. It refers to using mobile's phone functions, such as voice, SMS, GPS, Bluetooth and mobile telecommunications systems, to achieve health-related outcomes (World Health Organization, 2011). Data shows that starting with 2014, almost half of the global population was using some form of mobile communications (World Health Organization, 2015), and by 2025 is forecasted to have over 7 billion smartphone users in the world (Bankmycell, 2021).

Types of mHealth applications

All mHealth products have at least one of the following key components (World Health Organization, 2011)**:**

- Wearable technology
- Mobile phones
- Wireless devices
- Cloud computing and smart sensors
- Medical sensors
- Big data
- Data Collection Software
- Patient monitoring devices
- SMS (Short Message Service) and MMS (Multimedia Messaging Service)
- Mobile phone applications

- Bluetooth
- GPS (Global Positioning Systems) and GPRS (General Packet Radio Service)
- Wireless mobile telecommunications technology (3G; 4G; 5G – latest on the market)

With the rapid advancement of mobile communication, an array of health applications emerged on the market. These mHealth applications can be classified as follows:

1. mHealth apps for health promotion and prevention – these types of health apps focus on specific determinants of health to help with the prevention of diseases. These apps are specifically relevant for preventing non-communicable diseases since lifestyle factors are responsible for most of them (Davies & Mueller, 2020).

Example: mHealth app for enhancing physical fitness in healthy adults (Stork et al., 2021)

2. mHealth apps for health management - help patients and providers manage diseases, particularly non-communicable diseases such as diabetes, chronic respiratory conditions, cancer, and specific mental health problems (Davies & Mueller, 2020).

Example: mHealth app for management of atrial fibrillation (Guo et al., 2017)

3. mHealth apps for remote access to treatment - help patients receive access to treatment by facilitating contact with the healthcare providers and receiving effective treatments from the app itself. These apps are helpful, especially for people living in remote or underserved areas, people with mobility issues, and people with competing responsibilities (Davies & Mueller, 2020).

Example: mHealth app for management of atrial fibrillation during COVID-19 (Velden et al., 2020)

Purpose of mHealth applications

A lot of research and usability of mHealth focused only on health applications for personal use (e.g. monitoring calorie intake)(Smahel et al., 2017). Still, significant evidence shows that these applications can be used to improve patients' quality of life and health and improve patient-provider communication (Soriano et al., 2018; Zapata et al., 2015). Results show that mHealth has the potential of information and education related to chronic diseases, such as asthma, diabetes, HIV, coronary heart disease, for which mHealth apps offered significant improvements in reducing severe symptoms and helping with the management of the disease (Soriano et al., 2018; Youfa et al., 2020). Moreover, mHealth showed promising results in offering people decision support aid related to physical activity outcomes, smoking cessation, and sexual behavior outcomes (Soriano et al., 2018). Another common feature of mHealth lies in improving communication and interaction between

patients and providers, results showing better antenatal care, increased attendance rates to health care appointments, improved adherence to treatment, improvement of diagnostic rates, enhanced data collection and reporting medical information and reducing the costs associated with health (Soriano et al., 2018).

Advantages and disadvantages of mHealth applications

mHealth applications can offer increased advantages in the constant availability of personal health data, affordability, time and resources optimization, and the multitudes of options and functions in an app (Vervier et al., 2019). The scale-up potential of mHealth apps also offers an advantage in creating best practices to improve health promotion (L'Engle et al., 2017). mHealth applications also allow tailoring the health interventions according to the group's specific need, making it easier to reach more people and offer needs-related care due to the widespread availability of mobile devices and anonymity mHealth offer to users (Davis et al., 2020). Overall, mHealth apps encourage research and offers advances in the field.

However, the mHealth applications do not come without disadvantages. Lack of data protection, monitoring by third parties, lack of regulations related to mHealth apps, lack of personal contact, reduced engagement, no possibility of asking direct questions, constant data collection by the app, and the dependence on a mobile phone, were all factors identified as disadvantages of mHealth (Vervier et al., 2019). Moreover, the high dropout rates of using health apps (users usually decide within the first 3–7 days if they continue with the app) and technical failures of the app are other disadvantages that slow down the adoption of mHealth solutions (Davies & Mueller, 2020). Access to mobile phones in some parts of the world is still only available to men, while women cannot own them due to their high cost or independence status of the woman, creating gender inequalities in mHealth. Studies show that most females share or "borrow" phones and that the majority of the phone borrowers are from rural areas (LeFevre et al., 2020). Mobile services availability is still limited in many rural areas and the cost of phones, mobile services and Internet connection is still very high compared to monthly income in many world areas. Even in areas where services are available, the coverage is not reliable. Many users have to walk to other villages or to the top of a hill to use their phones (LeFevre et al., 2020). . In some areas of the globe, less than half of the population is literate, and the rates of digital health literacy and even lower, data showing that people have difficulties using a basic mobile phone or sending a text message (LeFevre et al., 2020; Messner et al., 2019). Moreover, in some parts of the world, the acceptability of mHealth

interventions is low due to lack of functionality, dissemination of false information, misdiagnosis, mistreatment and unknown or unwanted side effects (Messner et al., 2019).

Nonetheless, mHealth is a field that has tremendously developed in the past decades and continues to grow. Therefore, more digital health education is needed to fully understand the full potential of mHealth to improve the health and quality of life of groups and communities.

Digital health education and mHealth

According to the WHO, the effectiveness of digital health education and outcomes vary broadly depending on the learning objectives. Different types of digital health education (e.g. online digital education, mobile phones, virtual reality, and gamification), delivery mode (e.g. fully digital or blended), instructional method (e.g. simulations, direct instruction), assessment methods (i.e. use of validated or non-validated instruments), learning pedagogies (e.g. digital problem-based learning or digital team-based learning), study population (e.g. nurses, allied health professionals, doctors), and the topic, discipline and health condition being taught (e.g. smoking cessation, diabetes management, domestic violence, antibiotic management, dermatology, child health, elderly care), all impact the learning outcomes (World Health Organization, 2020).

The digital divide phenomenon may be a significant barrier for students because of the unequal access to digital education among countries (World Health Organization, 2020). Additionally, further research, evaluations, collaborations and investments are required to enhance methods for digital educations' effective use (World Health Organization, 2020).

One method for shaping digital education might approach a combination of knowledge, skills, and professional attitudes in the clinical or public health fields. For example, effective communication between patients and healthcare professionals in the clinical context includes knowledge of ethics, sociology, psychology, interpersonal skills, and attitudes (Fox et al., 2017).

Exercise: Based on the list of previous mHealth limitations available in this chapter, what do you think are some of the key limiting factors for mHealth in your country? Please respond in the discussion section.

3. Lesson plans for the mHealth module

[The objective of this section is to provide the foundational knowledge for each concept studied in a lesion plan and offer real-life, practical examples of all the concepts studied in the module. This will be done with the help of lessons plans, during which each concept is explained and exemplified with analogies of real-life examples. Lesson plans will include examples, analogies, application of the concepts, and areas for further enquiries for participants. Each lesson plan should have the format from below. There are 10 weeks of intensive study program with a total of 40 hours for the entire curriculum, so a maximum of 5 lesson plans, each with the duration of one hour should, be developed for every module since we have 5 hours allocated for every module]

[This part should ideally not exceed 30 pages]

Lesson plan 1: Introduction to Mobile Healthcare (mHealth)

Foundational knowledge

[For each lesson plan, please include a detailed explanation of the concepts, theories, models, terminology, principles, and methods currently used related to the concept explained in this lesson plan. In doing so, please create synergies within the two domains (IT and health and social science) to create mutual understanding among students]

Used terminology in the field

Mobile health (mHealth) solutions can improve access to health information and services for underserved populations and generate cost efficiencies and improve the capacity of health systems to provide quality health services (World Health Organization, 2011). Due to these potential benefits, many countries embrace mHealth approaches to strengthen their health systems and mHealth is often regarded as a game-changing practice for improving health (World Health Organization, 2011). mHealth can transform patient care and provide better access to essential health information (e.g. from tracking fitness achievements to allowing real-time remote consultations with physicians) (Lindgardt et al., 2014).

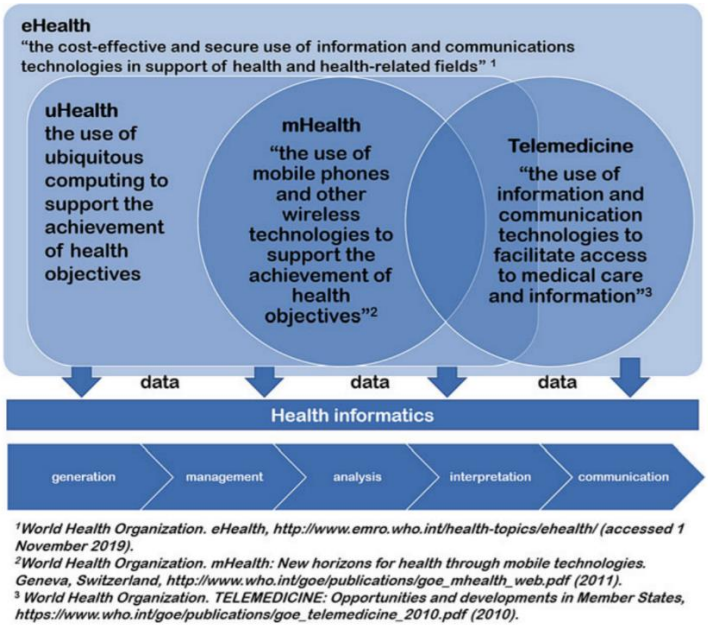
Before further discussion of mHealth and health applications, clarification of the most common terminology in this field is required.

The term mHealth is often used interchangeably with eHealth, which is not entirely accurate as mHealth represents a subdomain of eHealth (World Health Organization, 2011). According to the definitions provided by the WHO, eHealth is defined as “the cost-effective and secure use of information and communications technologies in support of health and health-related fields, including health care services, health surveillance, health literature, and health education, knowledge and research” (World Health Organization, 2021). At the same time, WHO’s definition of mHealth is “the use of mobile phones and other wireless technologies to support the achievement of health objectives” (World Health Organization, 2011). Therefore, mHealth is just a sub-component of the larger field of eHealth.

Another term related to mHealth is uHealth, which uses ubiquitous technology for health care and health promotion. Ubiquitous technology refers to devices embedded with processors, such as mobile devices, enabling them to connect to the Internet. Examples of such devices are smartwatches, tablets, smartphones, other activity trackers, and biometric or wearable devices (Davies & Mueller, 2020). Since trackers are involved in medical objects (e.g. in hospital beds to show real-time availability of beds), mHealth is also connected to the telemedicine field, sometimes overlapping. Telemedicine is defined as the “use of information and communication technologies to facilitate access to medical care and information”. It uses video calls, voice calls, text and multimedia messages, and e-mails for medical consultation and communication (World Health Organization, 2010).

Another term that is used synonymously with eHealth is health informatics. Health informatics usually refers to the “generation, management, analysis, interpretation and communication of health data” (Davies & Mueller, 2020). This can be achieved by using Information Communication Technology (ICT), which facilitates the usage of information and the sharing of knowledge by electronic means (Moss et al., 2019). Usually, ICT encompasses everything from the Internet, computers, servers, teleconference systems, radios, televisions, landline telephones, telemedicine devices, mobile telephones and other wireless devices (Moss et al., 2019).

A visual representation of how these topics are connected in the field of digital health can be found in the figure below.



(Davies & Mueller, 2020)

mHealth technology

mHealth practice uses mobile phones and other wireless technologies. These include basic phones, feature phones, smartphones, and tablets, as well as remote sensors and wireless-enabled diagnostic devices. Mobile phones and tablets are most commonly used in mHealth in low resource settings (Moss et al., 2019).

Below are the features commonly available on different types of mobile devices:

Basic Phone- voice calls and voice mail, SMS, USSD (Unstructured Supplementary Service Data - enables instant messaging and other services on basic mobile phones), SMS – or USSD-based services (mobile money, instant messaging) (Global Health eLearning Center, 2013).

Feature Phone – as basic mobile phone, plus: MMS (Multimedia Message Service, or text messages with photos or video embedded), still picture camera, music player, GPS (Global Positioning System) – most phones, 2.5G data access, Java-enabled (can download and/or use data collection forms, treatment algorithms and other applications that were programmed using Java for mobile phones, a software language explicitly designed for mobile phones), removable memory card – some phones,

ability to install and use applications – some phones, web browser – some phones (Global Health eLearning Center, 2013).

Smartphone – as feature phone, plus: video camera, web browser, GPS, internet access (3G, 4G, 5G), mobile operating platform (Android, iOS, Windows phone OS, and Symbian. Etc.), ability to use and install applications, VoIP (Voice over Internet Protocol - refers to a way to make phone calls over the Internet rather than through the user's cellular company network; Requires an Internet connection), removable memory card, video calls, touchscreen with a virtual or physical keyboard (Global Health eLearning Center, 2013; Hamed et al., 2017).

Smartwatches – devices with a computer system embedded in a wristwatch. Smartwatches are connected to the Internet and offer many functionalities that enable them to collect, process and react to outside stimuli. These devices usually can connect to other devices and share data. Some of the most common functionalities of a smartwatch are: heart rate monitor, pedometer, reminders for different behaviors, advice for users (Future Learn, 2021).

Tablet and portable laptop – video and still-picture cameras, web browser, GPS, internet access, ability to download and use applications, VoIP, large screen size and memory, faster processor, enabling video playback, touchscreen with virtual keyboard (Global Health eLearning Center, 2013).

Other mHealth technologies include patient monitoring devices, telemedicine devices, data collection software, chatbots, health applications (Adibi, 2015).

mHealth potential and opportunities

The rapidly increasing availability of wireless Internet and the use of smartphones and data sensors provide a solid foundation for growth (Lindgardt et al., 2014).

There are four primarily converging factors offering growth potential for the mHealth field (Qiang et al., 2012):

- Unprecedented growth of mobile phone users
- Rapid expansion of mobile networks
- Innovation in mobile technology
- Task shifting/sharing and other health system needs in developing countries

Factor 1: Growth of Mobile Phone Users

There are 5.27 billion unique mobile phone users in the world today, according to the latest data from GSMA Intelligence. The total number of individual mobile users around the world grew by 117 million in the past 12 months (Data Reportal, 2021).

Factor 2: Expansion of Mobile Networks

Seeking new markets, mobile telecommunications companies are extending their networks further into rural areas, surpassing the reach of other infrastructure such as roads, running water, electricity, and fixed telephone lines. Around 4.80 billion people worldwide use the Internet in July 2021; that's almost 61% of the world's total population. This number is still growing, latest data showing that 257 million new users came online over the past twelve months (Data Reportal, 2021). In contrast, before the expansion of mobile networks, many people in developing countries did not have access to a phone of any kind (Global Health eLearning Center, 2013).

Factor 3: Innovation in Mobile Technology

Mobile technology companies constantly innovate and improve mobile phones, wireless devices, and software applications, offering new possibilities for supporting health and health systems through mobile technology applications that can be adapted for different contexts and needs.

Factor 4: Task Shifting and other Health System Needs

mHealth solutions can help simplify task shifting and improve quality of care by providing health workers with checklists, decision tools and counselling algorithms on mobile phones. mHealth can also help expand community-based services and promote healthy behaviors by directly providing vital health education and behavior change messages to citizens. Data collection, medical records and logistics solutions using mHealth can introduce efficiencies in health systems (World Health Organization, 2011).

All these factors offer the opportunity for mobile devices to be used more and more for improving health. Development in technology is often used as a potential solution for healthcare crises. The health applications offer one such opportunity. Because of the extensive use of smartphones and

the Internet, health applications are viewed as cost-effective and scalable tools for disseminating significant health interventions towards the population (Davies & Mueller, 2020).

Healthcare applications can take the burden of the health care systems by helping people to self-manage their health (Davies & Mueller, 2020). Research data shows that health apps effectively improve clinical outcomes, physical functioning and biological parameters for diabetes, chronic lung diseases, and cardiovascular diseases (Whitehead & Seaton, 2016). A report from the UK on digital technologies showed that they could improve health services by freeing healthcare professionals time and offering them more time for diagnosis and treatment (National Health Service, 2019). Health applications can be useful for health professionals to improve communication, decision making, and health record management (Ventola, 2014).

Common features of mHealth apps

Each health app is a complex intervention with various features and functions tailored to the users' needs to promote health and improve their quality of life. Almost all health apps contain information and education, mostly coupled with decision making aid for the users under the form of recommendations (Davies & Mueller, 2020). Another feature of health apps is the behavior change support, which can be materialized in reminders and different other nudges. Self-assessment and monitoring are other functionalities that health apps use for keeping track of symptoms over time and helping medical providers with decision making on the type of treatment. mHealth features also include communication and interaction using varied device functionalities (e.g. messages, video calls, etc.) to facilitate rapid communication (Davies & Mueller, 2020). Finally, one essential feature for health apps is the theory-based interventions, meaning the health app is grounded in an existing and tested theory for behavior change. All these features increase the usability and success of health apps in improving people's lives (Davies & Mueller, 2020).

Examples and analogies

[For each lesson plan please provide examples and analogies that show how the concept can be applied in real life, focusing on standards for quality and qualification within the two domains (IT and health and social science)]

Examples of mHealth include:

- Community health worker consulting a maternal and child health information on a mobile phone to offer recommendation for a patient (World Health Organization, 2011).
- Free text-message services used by citizens to obtain information about family planning methods (World Health Organization, 2011).
- An application tracking the symptoms of the COVID-19 in the population (Giansanti, 2021).
- mHealth technologies used by biopharmaceutical companies to reduce costs (e.g. by conducting clinical trials remotely) and generate new sources of revenue through improved compliance (e.g. providing innovative packaging that reminds patients when to take their medication) (Lindgardt et al., 2014).
- Medical-technology companies can provide technological support for mHealth by developing solutions to patient care, such as mobile devices that transmit data to physicians or digital imaging (Lindgardt et al., 2014).
- Providers can develop innovative ways to manage communication between patients and physicians by expanding remote-consultation services into hard-to-reach areas (Lindgardt et al., 2014).

Here are some examples of mobile health apps available on the market that are being most used: [MAYBE ADD SCREENHOTS FROM THE APP? – DISCUSS THIS WITH EBI IN THE NEXT PHASE]

- Fitbit
- Apple Heart Study
- GoogleFit
- Samsung Health
- AliveCor's KardiaMobile
- BlueStar

Mobile for Reproductive Health (m4RH) is a free text message service that provides information about family planning methods and can be used on a simple mobile phone. Users request the service, or "opt-in," by sending the text "m4RH" to a toll-free, four-digit number or short code. The user then receives a menu-based message, and to request information about a particular method, the user texts the two-digit code shown in the menu (such as "21" for IUD). The user receives a text message with information on the method's effectiveness, how long it works or how often it is used, any side effects, and return to fertility after stopping (Olsen et al., 2018).

FrontlineSMS is a free, open-source group-messaging platform that works with a laptop connected to a mobile phone or modem. It allows users to send, receive and handle text message interactions with large groups of people. The software works without Internet access and is easy to set up and operate (Banks et al., 2011).

CommCare is a case management application for community health workers that has been used in community-based maternal and child health projects. The free software runs on low cost, java-enabled mobile phones as well as more sophisticated Android smartphones. The application contains registration forms, checklists, danger sign monitoring and client education tools (Duffy et al., 2019).

Application and integration

[For each lesson plan please provide exercises and practical activities that will help students apply what they have learned about this concept. For this section non-formal activities are strongly advised to be used]

Exercise 1: Did you ever use a mHealth app aimed to track/monitor your health? If yes, which one? Did it help you in any way? What would you change (add/remove) on that specific app, and why?

If you have never used a mHealth app, can you think about a useful app that should be available on the market?

Please respond in the discussion section.

Exercise 2: Can you think about health challenges in your country that can be (partially) solved by using mHealth? Please select a health challenge and explain what mHealth solution would be the most suitable and why.

References for further information and areas on inquiries

[For each lesson plan please provide references and connected areas for students to further inquiry and read more about. There are 20hrs of individual work for the entire curriculum, which means 2.5 hours for each module, so 30 minutes for each lesson plan (if you decide to have 5 lesson plans). Books, scientific publications, and other activities connected with the topic of the modules can be offered as references in this section]

More in-depth reading and documentation from the articles referenced above

+

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2. Taylor, K., & Silver, L. (2019). Smartphone ownership is growing rapidly around the world, but not always equally. Pew research center, 5, 2019..

3. Whitehead, L., & Seaton, P. (2016). The effectiveness of self-management mobile phone and tablet apps in long-term condition management: a systematic review. Journal of medical Internet research, 18(5), e4883.

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4. Davies, A., & Mueller, J. (2020). Introduction to mHealth. In Developing Medical Apps and mHealth Interventions (pp. 1-24). Springer, Cham.

5. mHealth Training Institute - 2021 Lectures (2021, October 17). Retrieved from: https://mhti.md2k.org/index.php/gallery/2021-1/2021-lectures

6. myElearning: my mHealth (2021, October 17). Retrieved from: https://learn.mymhealth.com/our-courses/

7. Connecting community health workers to supervisors and district clinics via SMS: https://www.youtube.com/watch?v=lKZ0u4bk-dQ

Lesson plan 2: Behavioral theories/models for mHealth

Foundational knowledge

[For each lesson plan please include a detailed explanation of the concepts, theories, models, terminology, principles, and methods being currently used related to the concept explained in this lesson plan. In doing so please create synergies within the two domains (IT and health and social science) to create mutual understanding among students]

Health behavior change programs and interventions have a good track record at effectiveness for numerous lifestyle behaviors such as weight loss, dietary changes, smoking cessation, physical activity, treatment adherence and disease management (Salwen-Deremer et al., 2019). However, designing and implementing such health behavior change programs might be problematic due to the complex nature of human behavior (Wang et al., 2019). These change programs often require different practices and theories from diverse fields such as public health, economy, psychology, or human-technology interaction (Wang et al., 2019).

Research in the field has shown that these interventions and programs are most effective when they are based on evidence-based strategies and theoretical models and concepts (Glanz & Bishop, 2010; Webb et al., 2010) and delivered in-person. However, good results can be achieved when these are delivered remotely using telephones, mobile phones, smartphones and wearable devices (Cho et al., 2018; Salwen-Deremer et al., 2019). Still, data suggests that even with this knowledge, studies consistently show that the inclusion of traditional behavioral change theories is suboptimal in most interventions using mHealth apps (Cho et al., 2018; Salwen-Deremer et al., 2019). Moreover, researchers have indicated that it is difficult to replicate mHealth interventions as they do not offer details about their concepts' structure, content, and evidence base (DeKoekkoek et al., 2015). Therefore, this lack of replicability poses challenges in demonstrating that mHealth apps effectively employ evidence-based behavioral theories, models and strategies for changing behavior (Salwen-Deremer et al., 2019).

Before continuing, some definitions related to behavior change are needed:

Behavioral change theories are defined as “a set of concepts and/or statements which specify how phenomena relate to each other. A theory provides an organizing description of a system that

accounts for what is known, and explains and predicts phenomena" (Davis et al., 2014). The theory is essential in health behavior change because it provides a mechanism to condense all previous knowledge about different variations in a causal factor to produce an effect. An intervention could represent a causal factor, while the effect can be the actual behavior change (Hekler et al., 2016).

Behavioral change models are defined as concepts that "help us understand specific behaviors, by identifying the underlying factors, which influence them" (Darton, 2008).

The main difference between behavior change models and theories is that models help us understand behavior. In contrast, theories of change demonstrate how behaviors can be changed and how they change over time (Darton, 2008). In other words, the theories of change offer the framework for behavior change, while the models provide the necessary tools to make that specific behavioral change.

Multiple behaviour change theories aim to modify behavior and help prevent diseases (Salwen-Deremer et al., 2019). Further, we will explore some traditional behavior change theories and some contemporary behavior change theories that have evidence-based solid support for their use in mHlealth. We will also observe the interaction between these theories and how that interaction can be harnessed for mHealth apps.

Traditional Theories and Models of Behavior Change

The theories most used in lifestyle interventions with good scientific results are Social Cognitive Theory (SCT), Theory of Planned Behavior (TPB), The Health Belief Model (HBM) and the Trans-Theoretical Model (TTM) (Salwen-Deremer et al., 2019). However, other behavior change theories exist, but they are not widely supported according to the latest research, so their results cannot be generalized (Salwen-Deremer et al., 2019).

Social Cognitive Theory (SCT) claims that there is a reciprocal relationship among the person, their behavior and the environment. This theory emphasizes on social influence and the importance of external and internal social reinforcement (Bandura, 1996). The SCT has the following components that need to be addressed when designing health change interventions and behaviors:

1. Reciprocal Determinism is the central concept of SCT. It refers to the dynamic and reciprocal interaction of a person (individual with a set of learned experiences), the environment (external social context), and the behavior (responses to stimuli to achieve goals) (Bandura, 1996).

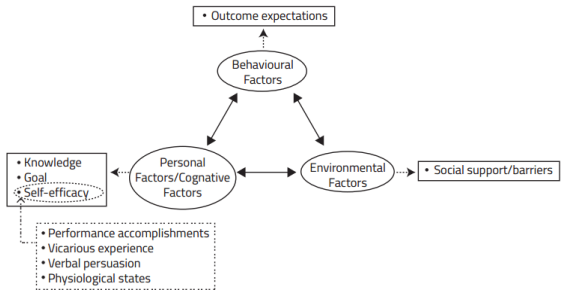
2. Behavioral Capability refers to a person's actual ability to perform a behavior through essential knowledge and skills. To accomplish the desired behavior, the person must have the knowledge to do it. People learn from both the consequences of their behavior and the environment in which they live (Bandura, 1996).

3. Observational Learning means that people can witness and observe a behavior conducted by others and then reproduce those actions, a concept called "modelling" of behaviors. If people see a successful demonstration of behavior, they can also perform the behavior successfully (Bandura, 1996).

4. Reinforcements refer to the internal or external responses to a person's behavior that affect the probability of continuing or discontinuing the behavior. Reinforcements can be initiated by the person or existent in the environment, and reinforcements can be positive or negative (Bandura, 1996).

5. Expectations refer to the anticipated consequences of a person's behavior. People anticipate the consequences of their actions before engaging in the behavior, and these consequences can influence the successful completion of the behavior. Expectations derive primarily from previous experiences, and they focus on the value placed on the outcome and are subjective to the individual (Bandura, 1996).

6. Self-efficacy refers to the level of a person's confidence in the ability of performing a behavior successfully. Self-efficacy is influenced by a person's specific capabilities and other individual factors and environmental factors that can be perceived as barriers and facilitators (Bandura, 1996).



Social Cognitive Theory (Bandura, 1996)

SCT and mHealth

SCT was successfully used for mHealth applications in weight loss interventions (Burke et al., 2012), promoting physical activity (Baretta et al., 2019; Freigoun et al., 2017), chronic disease management (Whittemore et al., 2020), and smoking cessation (Ghorai et al., 2014).

Theory of Planned Behavior (TPB) intends to explain all behaviors over which people can employ self-control, and it is an extension of the Theory of Reasoned Action (TRA) (Ajzen, 1991). The key component of the model is behavioral intent. Behavioral intentions are shaped by the attitude about the likelihood of the behavior to have the expected outcome and by the subjective evaluation of the risks and benefits of the desired outcome (Ajzen, 1991). The TPB implies that achieving a specific behavior depends on motivation (intention) and ability (behavioral control). It makes the difference between three types of beliefs - behavioral, normative, and control. The TPB contains six constructs that collectively represent people's actual control over the behavior.

1. Attitudes refer to a person's degree to have a favorable or unfavorable evaluation of the behavior of interest. It requires the person to consider the outcomes of performing the behavior (Ajzen, 1991).

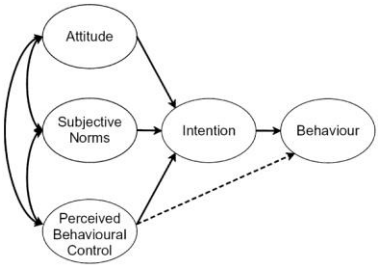
2. Behavioral intention refers to the motivational factors that influence a given behavior. If the intention to perform the behavior is strong, the behavior will most likely be performed (Ajzen, 1991).

3. Subjective norms refer to the thoughts about whether most people approve or disapprove of the behavior. It relates to a person's beliefs about whether peers and people of importance think they should engage in the behavior (Ajzen, 1991).

4. Social norms refer to the specific behaviors of a group of people or a larger cultural context. Social norms are considered usually to dictate in a group of people (Ajzen, 1991).

5. Perceived power refers to the perceived presence of factors that may facilitate or impede the performance of a behavior. Perceived power contributes to a how a person perceives behavioral control over each of those factors (Ajzen, 1991).

6. Perceived behavioral control refers to a person's perception of how easy or difficult is to perform a specific behavior. Perceived behavioral control may vary across situations and actions, resulting in multiple perceptions of behavioral control depending on the situation (Ajzen, 1991).



Theory of Planned Behavior (Ajzen, 1991)

TPB and mHealth

TPB was successfully used for mHealth in preventing alcohol abuse (Kazemi et al., 2017), diabetes management (Samer & Al-Shami, 2020), dietary weight loss and physical activity (Salwen-Deremer et al., 2019), and coping with chronic diseases (Guido et al., 2018).

The Health Belief Model (HBM) implies that a person's belief in a threat of an illness or disease coupled with a person's confidence in the effectiveness of the recommended health behavior or action will predict the likelihood the person to adopt the behavior (Ogden, 20112). HBM is composed of six constructs, as follows:

1. Perceived susceptibility refers to a person's subjective perception of the risk of developing an illness or disease. There is wide variability of how people perceive the chances of developing a disease (Ogden, 20112).

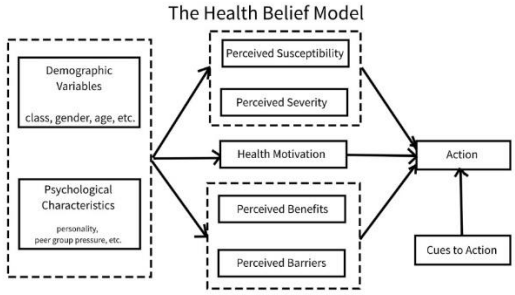
2. Perceived severity refers to a person's feelings on how severe an illness will be. When evaluating the severity, a person often considers the health consequences (e.g., disease or death) and social consequences (e.g. social relationships) (Ogden, 20112).

3. Perceived benefits refers to a person's assessment of the effectiveness of behaviors to reduce the threat of disease. The course of action in preventing (or curing) the disease is based on the perception that action is beneficial (Ogden, 20112).

4. Perceived barriers refers to a person's thoughts on the obstacles to performing a recommended health action. The person evaluates the usefulness of the actions against the idea that it may be expensive, dangerous, unpleasant, time-consuming, or inconvenient (Ogden, 20112).

5. Cue to action refers to the stimulus needed to trigger the decision to accept a recommended health action. The cues can be internal (disease symptoms.) or external (e.g., advice from others, illness of someone close newspaper article, etc.) (Ogden, 20112).

6. Self-efficacy refers to the person's confidence in their ability to undertake the behavior (Ogden, 20112).



Health Belief Model (Ogden, 20112)

HBM model was found to be successful in mHealth apps targeting HIV testing (Evans et al., 2016), screening for cervical cancer (Khademolhosseini et al., 2017), tobacco control (Ali et al., 2020), and tracking infectious diseases – such as COVID-19 (Michel et al., 2020).

Trans-Theoretical Model (TTM) focuses on the decision-making of the individual and is a model of intentional change, considering that people do not change behaviors quickly (Prochaska, 2013). The TTM states that a person moves through different stages when modifying behavior. Various intervention strategies are most effective at each stage to move the individual to the next step (Prochaska, 2013). The TTM stages are:

1. Precontemplation. In this stage, people do not desire to take action and are often unaware that their behaviors negatively affect their health (Prochaska, 2013).

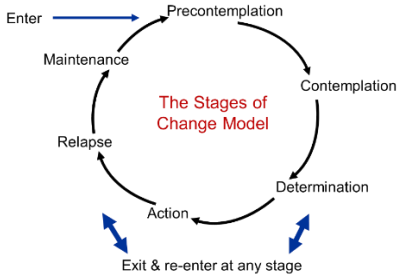
2. Contemplation. In this stage, people recognize that their behavior may influence their health. Even with this recognition, people may still feel ambivalent toward changing their behavior and may not take action towards it (Prochaska, 2013).

3. Preparation (Determination). In this stage, people are determined to take action and start taking steps toward behavior change (Prochaska, 2013).

4. Action. In this stage, people have just changed their behavior, which is considered to be within 6 months of actively pursuing the behavior (Prochaska, 2013).

5. Maintenance. In this stage, people sustain their behavior for more than 6 months and intend to maintain the behavior change. People in this stage actively work to prevent relapse to earlier stages (Prochaska, 2013).

6. Termination. In this stage, people will not return to their unhealthy behaviors. Since this is rarely reached, this stage is often not considered in health promotion programs (Prochaska, 2013).



Trans-Theoretical Model (Prochaska, 2013)

TTM has successful results in mHealth application on obesity prevention (Lee et al., 2017), diabetes prevention (Jennings et al., 2019), mental health (Frith & Loprinzi, 2017), eating behavior (Abdel-Fatah Ibrahim et al., 2017), and smoking cessation (Chahar et al., 2018).

Contemporary Behavior Change Theories

Contemporary theories emerged once with the development of mHealth apps towards more interactive and adaptative functions that required more than just the components of traditional behavior theories presented above (Salwen-Deremer et al., 2019). Fogg Behavior Model, Internet

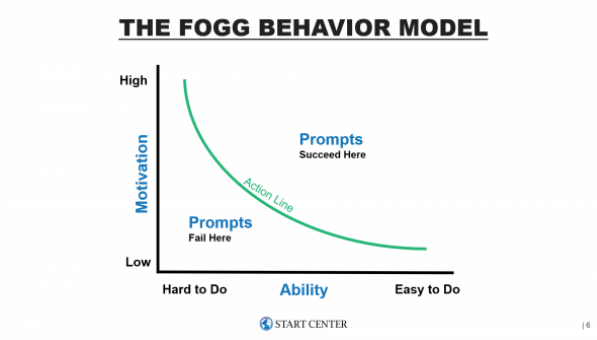
Intervention Model (RIIM), and Persuasive Systems Design (PSD) model are some promising behavior change models that showed good results with mHealth apps (Salwen-Deremer et al., 2019).

Fogg Behavior Model is based on three dimensions that converge to prompt behavior change: motivation, abilities and prompts (Fogg, 2021).

1. Motivation refers to structures that facilitate behavior change, such as sensation (pleasure vs pain), anticipation (hope vs fear), and belonging (social acceptance vs rejection) (Fogg, 2021).

2. Abilities refer to both the person's skills and resources and the difficulty of the behavior. It is dependent upon time, money, physical effort, brain cycles (how mentally taxing a behavior is), social deviance (how socially acceptable a behavior is), and non-routine (routine behaviors are easier to perform) (Fogg, 2021).

3. Prompts refer to the constructs people need to make the behavior. They should be applied at the right time, such that the person has both motivation and ability present when the prompt occurs (Fogg, 2021).



Source: Fogg, BJ. The Fogg Behavior Model. 2018. Available from: http://www.behaviormodel.org/

Fogg Behavior Model was successfully used for mHealth interventions on dietary change and physical activity (Rabbi et al., 2015), preventing obesity (Militello et al., 2016), cervical screen cancer (Lee et al., 2014), and preventing the spread of COVID-19 (Alrige et al., 2021).

Internet Intervention Model (RIIM) suggests that internet-based interventions are effective if they follow the 9 nonlinear steps of the model, namely:

1. User characteristics refer to the patient, consumer, or research participant who bring their own diverse set of variables or characteristics that cannot be manipulated (e.g., age, gender, cognitive traits) and serve as predictor variables in developing an intervention (Ritterband et al., 2009).

2. Environment refers to multiple factors such as family, friends, employer, the community, which can either offer support or put barriers to adopting the behavior; therefore, it needs to be accounted for when developing an intervention (Ritterband et al., 2009).

3. Website refers to the program or application through which treatment is delivered and has eight main areas that need to be taken into account when developing the intervention: *appearance*, *behavioral prescriptions*, *burdens*, *content*, *delivery*, *message*, *participation* (Ritterband et al., 2009).

4. Website use refers to the actual utilization of the intervention. The other steps of the model highly influence it; therefore, special attention needs to be given to them when developing the intervention (Ritterband et al., 2009).

5. Support refers to how the person's feels they receive help to make the change. Support usually impacts adherence, ranging from emails and texts to other prompts (Ritterband et al., 2009).

6. Mechanisms of change are the catalysts of transformation and may take the form of knowledge, information, motivation, attitude, beliefs, skill-building, self-efficacy, cognitive restructuring and self-monitoring (Ritterband et al., 2009).

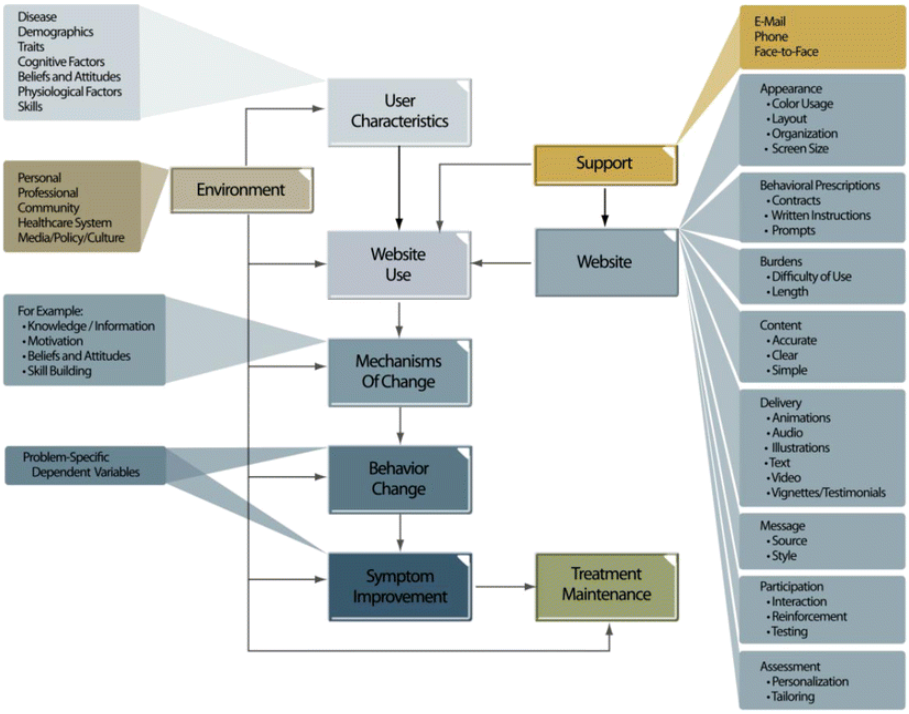
7. Behavior change is the ultimate variable of change, and it is critical to identify behaviors that are essential to change to reduce associated symptoms and achieve a positive outcome (Ritterband et al., 2009).

8. Symptom improvement is the goal of most interventions, and it refers to improving the wellbeing of the target group (Ritterband et al., 2009).

9. Treatment maintenance refers to including some form of relapse prevention in the intervention to help users maintain treatment gains (Ritterband et al., 2009).

The main idea that the model states is that "the user, influenced by environmental factors, affects website use and adherence, which is influenced by support and website characteristics. Website use

leads to behavior change and symptom improvement through various mechanisms of change. The improvements are sustained via treatment maintenance" (Ritterband et al., 2009).



Internet Intervention Model (Ritterband et al., 2009)

The Persuasive Systems Design (PSD) model helps design and evaluate persuasive systems and describes what content and software functions may be found in the final product of an intervention (Oinas-Kukkonen & Harjumaa, 2009). The model suggests that when designing or evaluating persuasive systems, aspects from the following figure should be considered (Oinas-Kukkonen & Harjumaa, 2009).

Table 1. Postulates behind Persuasive Systems	
1.	Information technology is never neutral.
2.	People like their views about the world to be organized and consistent.
3.	Direct and indirect routes are key persuasion strategies.
4.	Persuasion is often incremental.
5.	Persuasion through persuasive systems should always be open.
6.	Persuasive systems should aim at unobtrusiveness.
7.	Persuasive systems should aim at being both useful and easy to use.

Postulates behind PSD model (Oinas-Kukkonen & Harjumaa, 2009)

The PSD identifies three main areas of change: (1) forming a behavior or a cognition; (2) altering a behavior or a cognition; and (3) maintaining a behavior or a cognition (Oinas-Kukkonen & Harjumaa,

2009). The PSD model contains four key design features, each with a subset of components that can be used when designing behavior change interventions:

1. Primary task support includes reducing complex behaviors into simpler ones, tunneling experience, tailoring and personalization, self-monitoring, simulation, and rehearsal of the behavior (Oinas-Kukkonen & Harjumaa, 2009).

2. Dialogue support includes positive reinforcement (praise, rewards), reminders and suggestions, the similarity of actions, visual attractiveness (liking), and social role (Oinas-Kukkonen & Harjumaa, 2009).

3. Credibility includes trustworthiness, expertise, credibility, real-world resemblance, authority, verifiability, and third-party endorsements of the action (Oinas-Kukkonen & Harjumaa, 2009).

4. Social support includes social learning, social comparison, normative influence, social facilitation, cooperation, competition, and recognition (Oinas-Kukkonen & Harjumaa, 2009).

PSD model has been used for mHealth applications targeting the management of chronic diseases, such as cancer (Vlahu et al., 2021), anxiety (Radomski et al., 2019), stress management (Alhasani et al., 2020), and physical health (Halttu & Oinas-Kukkonen, 2017).

Interactions across Theories

The above models provide different explanations and concepts to achieve behavior change, but researchers demonstrated that they overlap substantially, and there are interactions in how these theories predict behavior (Salwen-Deremer et al., 2019). These findings indicate that behavioral health theories vary significantly among interventions and that they should be incorporated in intervention design based on the type of behavior change desired (Salwen-Deremer et al., 2019). Interdisciplinary teams need to work together in mHealth to advance knowledge. Behavioral scientists, psychologists, clinicians, software engineers, designers, and other professionals must share a common understanding of behaviour change theories. This shared knowledge will enable them to build mHealth technologies that are engaging and acceptable while also impacting and contributing to sustained behavior change and better health outcomes (Salwen-Deremer et al., 2019).

Examples and analogies

[For each lesson plan, please provide examples and analogies that show how the concept can be applied in real life, focusing on standards for quality and qualification within the two domains (IT and health and social science)]

All the mHeahlth interventions mentioned above will be cited here.

Application and integration

[For each lesson plan please provide exercises and practical activities that will help students apply what they have learned about this concept. For this section non-formal activities are strongly advised to be used]

Lessons 2, 3, 4, and 5 will have a common "Application and integration activity" consisting in designing an app to increase vaccination rates in the first year of life. The app should be designed for parents, while the beneficiaries will be children due to the fact that they receive their vaccines on time.

References for further information and areas on inquiries

[For each lesson plan please provide references and connected areas for students to further inquiry and read more about. There are 20hrs of individual work for the entire curriculum, which means 2.5 hours for each module, so 30 minutes for each lesson plan (if you decide to have 5 lesson plans). Books, scientific publications, and other activities connected with the topic of the modules can be offered as references in this section]

Other examples of Behavioral change theories:

1. https://sphweb.bumc.bu.edu/otlt/mph-modules/sb/behavioralchangetheories/index.html

2.https://sphweb.bumc.bu.edu/otlt/mph-modules/sb/behavioralchangetheories/BehavioralChangeTheories_print.html

Lesson plan 3: Current mHealth practice: Behavioral Intervention Technology (BIT) Model and TUDER framework

Foundational knowledge

[For each lesson plan please include a detailed explanation of the concepts, theories, models, terminology, principles, and methods being currently used related to the concept explained in this lesion plan. In doing so please create synergies within the two domains (IT and health and social science) to create mutual understanding among students]

In lesson 2 we reviewed some traditional and contemporary behavioral change theories and models, and we explored how they can be used for mHealth interventions. While these models have proved to be very useful to describe what cognitive and behavioral changes are required for people and their environment, they offer little information on designing mHealth interventions and evaluating their effectiveness (Riley et al., 2011). As digital health interventions (DHI) have increased rapidly, new taxonomies and frameworks are needed (Mohr et al., 2014; Wang et al., 2019). Therefore lesson 3 explores the Behavioral Intervention Technology (BIT) model and a holistic framework (TUDER) which combines behavioral theories, behavior change technique taxonomy, and persuasive system design principles to design and evaluate mHealth interventions.

Behavioral Intervention Technology (BIT) model

The behavioral intervention technology model consists of a framework for developing implementable interventions, and it is anchored in the contemporary behavioral change models presented in lesson 2 (Mohr et al., 2014). BIT offers the necessary steps of translating the behavior change theories and models into actions that need to be taken when designing and implementing a digital behavior change intervention. The BIT model proposes the “why”, “what”, “how”, and “when” for developing DHIs, which can be observed in the figure below.

		BIT component	Examples
Theoretical			
	Why	Aims	Clinical aims:
			Weight reduction:
			Decrease caloric intake
			Increase physical activity
			Promote sleep hygiene
			Decrease depression:
			Increase positive activities
			Decrease avoidance behaviors
			Usage aims:
			Use of Intervention tools
	How (Conceptual)	Behavior change strategies	Education
			Goal setting
			Monitoring
			Feedback
			Motivation enhancement
Instantiation			
	What	Elements	Information delivery
			Notifications
			Logs
			Passive data collection
			Messaging
			Reports
	How (Technical)	Characteristics	Medium
			Complexity
			Aesthetics
	When	Workflow	User defined
			Frequency
			Conditions:
			Time-based rules
			Task completion rules
			Event-based rules
			Tunneling

BIT model (Mohr et al., 2014)

1. *Why.* This component of the BIT model discusses the intervention aims, and it can refer to both clinical aims (e.g. reducing weight) or usage aims (e.g. maintaining the engagement with specific components of the intervention – like daily use of the mHealth app). These outcomes are most of the time overlapping; therefore, a usage aim is often reflected in the clinical aim and vice versa (Mohr et al., 2014).

2. What. This component of the BIT model refers to the actual behavioral intervention technologies the intervention offers to prompt behavior change. These can take the form of a data field for logging in the desired behavior (e.g. food consumption, sleep hours, etc.) to act as a behavior change strategy of monitoring (Mohr et al., 2014). Other examples of behavioral intervention strategies are notifications, app reports for users, logs, and visualizations; these elements are delivered separately or embedded together (Mohr et al., 2014).

3. How. This component of the BIT model offers both conceptual and technical strategies for behavioral interventions that help attain the intervention aims (Mohr et al., 2014). The conceptual strategies are based on theories and models of behavior change (presented in lesson 2) and are crucial for behavior change to occur and be maintained. A list of conceptual strategies, developed upon an extensive taxonomy of behavior change strategies (Michie et al., 2013), is offered by the BIT model to attain behavioral change (Mohr et al., 2014). The technical strategies are used to offer the user a good experience with the app in terms of engagement, ability to complete tasks, and app comprehension. These strategies can vary in complexity, media employed, aesthetics, and personalization depending on the needs of the interventions and the characteristics of the users (Mohr et al., 2014).

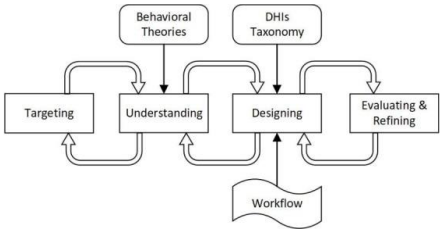
4. *When.* This component refers to the workflow of the intervention and defines under what conditions the intervention is delivered. Some common examples of workflow elements are: (1) tunnelling – the use of data to decide which interventions meet the needs and preference of users in a specific time period; (2) frequency – how frequent the intervention is offered; (3) conditions – the use of data to determine when should an intervention be delivered (it can be time-based, task-completion, and event-based); (4) user-defined – offers access to all elements of the intervention from the beginning, allowing the user to set the sequence and timing of the app (Mohr et al., 2014). Usually, workflows integrate a number of these elements to achieve behavior change, depending on the needs of the interventions and the characteristics of the users (Mohr et al., 2014).

The BTI model can be useful for mHealth app developers to decide on the app design and clarify their intentions, aims, and intervention conceptual and technical elements (Mohr et al., 2014). It was successfully used for fitness applications, such as MyFitnessPall (Mohr et al., 2014).

TUDER framework

TUDER is a holistic framework that aims to "integrate the advantages of behavioral theories, Behavior Change Techniques (BCT) taxonomy, and persuasive technology design principles to researchers design, evaluate, and report their studies in a formative and comprehensive way" (Wang et al., 2019). The TUDER framework goes a step further from the BIT model and offers a unified taxonomy considering the contemporary models presented in lesson 2 and the BIT model presented above. The framework can be really useful not only to develop the intervention but also to evaluate it (Wang et al., 2019).

The TUDER acronym comes from the following four steps comprising the framework: Targeting, Understanding, Designing, Evaluating and Refining.



TUDER holistic framework (Wang et al., 2019).

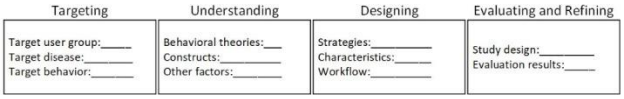
1. *Targeting the users, health problem and behavior.* This component highlights the importance of tying the user group, the health problem, and the desired behavior to achieve the intervention's aim. An example from the authors of the frameworks is "an intervention to promote the use of standing desks (the behavior) to reduce the prolonged sedentary behavior (the behavior) of office workers (the user group) to prevent chronic diseases, such as type 2 diabetes (the health problem)" (Wang et al., 2019).

2. *Understanding.* This component of the framework considers the behavioral theories (or models/constructs) that need to be used to change the behavior tacked by the intervention (Wang et al., 2019).

3. *Designing the intervention, characteristics, and workflow*. This component refers to the intervention strategies and DHI characteristics that need to be considered when designing an intervention. The framework offers 98 intervention strategies and 6 intervention characteristics to be used for developing mHealth apps. Moreover, the framework also includes the importance of workflows, a concept borrowed from the BIT model (Wang et al., 2019).

4. *Evaluating and Refining the Intervention Design.* A novel approach of the TUDER framework is the importance offered to constant evaluation of the intervention design. The framework suggests that usability evolution (regarding human-computer interaction and uptake) and effectiveness evaluation (regarding behavior change and impact) should be considered when designing an intervention. The framework provides suggestions for refining the intervention, such as think-aloud, cognitive walkthrough, pilot-testing, and heuristic evaluations (Wang et al., 2019).

A checklist was also developed for standardized use and reporting of the framework (Wang et al., 2019).



TUDER framework checklist (Wang et al., 2019).

Examples and analogies

[For each lesson plan please provide examples and analogies that show how the concept can be applied in real life, focusing on standards for quality and qualification within the two domains (IT and health and social science)]

BIT model

1. A practical example of BIT mode is the MyFitnessPall application, explained in the following article:

Mohr, D. C., Schueller, S. M., Montague, E., Burns, M. N., & Rashidi, P. (2014). The behavioral intervention technology model: an integrated conceptual and technological framework for eHealth and mHealth interventions. Journal of medical Internet research, 16(6), e3077.

2. Another practical example of the BIT model is for an mHealth app targeting sedentary behaviors explained in the following article:

Direito, A., Walsh, D., Hinbarji, M., Albatal, R., Tooley, M., Whittaker, R., & Maddison, R. (2018). Using the intervention mapping and behavioral intervention technology frameworks: development of an mHealth intervention for physical activity and sedentary behavior change. Health Education & Behavior, 45(3), 331-348.

3. BIT model used for developing an mHealth app for self-management of addictive behaviors, in the following article:

Beck, A. K., Kelly, P. J., Deane, F. P., Baker, A. L., Hides, L., Manning, V., ... & Martini, M. (2021). Developing a mHealth Routine Outcome Monitoring and Feedback App ("SMART Track") to Support Self-Management of Addictive Behaviours. Frontiers in Psychiatry, 12, 820.

TUDER framework

1. Part of this framework has been used to guide the development of a personalized leisure time physical activity application which is described in the following paper:
Sporrel, K., De Boer, R. D., Wang, S., Nibbeling, N., Simons, M., Deutekom, M., ... & Kröse, B. (2020). The Design and Development of a Personalized Leisure Time Physical Activity Application Based on Behavior Change Theories, End-User Perceptions, and Principles From Empirical Data Mining. Frontiers in Public Health, 8.

2. The underpinnings of the TUDER framework have been used to develop a wHealth care pathways for patients with lifestyle-related chronic diseases:
Cardol, C. K., Tommel, J., van Middendorp, H., Ciere, Y., Sont, J. K., Evers, A. W., & van Dijk, S. (2021). Detecting and treating psychosocial and lifestyle-related difficulties in chronic disease: Development and treatment protocol of the e-goal ehealth care pathway. International journal of environmental research and public health, 18(6), 3292.

References for further information and areas of inquiries

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1. Myneni, S., Amith, M., Geng, Y., & Tao, C. (2015). Towards an ontology-driven framework to enable development of personalized mHealth solutions for Cancer survivors' engagement in healthy living. Studies in health technology and informatics, 216, 113.

2. Mohr, D. C., Tomasino, K. N., Lattie, E. G., Palac, H. L., Kwasny, M. J., Weingardt, K., & Schueller, S. M. (2017). IntelliCare: an eclectic, skills-based app suite for the treatment of depression and anxiety. Journal of medical Internet research, 19(1), e10.

Lesson plan 4: mHealth software project management and development

Foundational knowledge

[For each lesson plan please include a detailed explanation of the concepts, theories, models, terminology, principles, and methods being currently used related to the concept explained in this lesion plan. In doing so please create synergies within the two domains (IT and health and social science) to create mutual understanding among students]

Disclaimer: Part of the examples presented in this Lesson are taken from a real-life mHealth app called Smoke Free Together. The development and testing of the app were funded through the grant "A Smartphone Intervention for Pregnancy Smoking Cessation with Peer Support (R21-HD103039-01)" from the National Institutes of Health (USA) and competitively awarded to a consortium of four universities (Michigan State University, Wake Forest School of Medicine, Michigan University, and Babes-Bolyai University). The Smoke Free Together smoking cessation mobile app was designed to be used by pregnant women and one nominated peer supporter of their choice. The summary of the funded research project can be accessed here (NIH RePORTER, 2021).

1. Elements of an mHealth product

The following are considered the main elements of an mHealth product:

- The *platform* is a software application or suite of applications that provide the mobile device functionalities needed for the mHealth intervention.
- The *content* may include health education for clients, health worker decision tools and counseling aids, data collection forms, or a combination of applications.
- The *user interface* is the way that the content is presented to the end-user—such as through menus, text, video, audio messages, and drawings.

2. Roles in a mHealth software project

The focus of this Lesson is on providing a mix of theoretical principles and hands-on examples that are useful when managing the development of a mHealth application. The first aspect that needs to be considered represents the structure of the team working on such a project. At a minimum, the team needs to consist of at least one individual who meets each one of the roles described in the table below. The roles of the team members are described in a simplified manner, the aim being to offer an overview of the distinction between the responsibilities of each team member.

Role	Description
Project sponsor	This is the individual, organization, institution, or company that provides the resources for the development of the mHealth app. For example, the Ministry of Health can decide to sponsor a mobile app for parents to boost vaccination rates and coverage.
Project manager	The role of this team member is to make sure that the work that needs to be done fits the available budget and to track the progress of the project against pre-set milestones, deliverables, and deadlines. In some cases, this person will also recruit other staff members.
Product owner	This member of the team has several different types of responsibilities: to communicate with and across stakeholders to define and maintain the vision of the product during the development phase; to manage and prioritize the tasks in the product backlog; and to evaluate the product progress at each iteration.
Developers	The job of the developers is to use the technical requirements of the software and to produce code in line with the requirements. In most software development projects there are three types of developers involved: a full-stack developer, a front-end developer, and a back-end developer.
Tester	The tester will not use the app from the perspective of an end user but use it from an analogical approach. The job of the tester is to stress test the app and to find its pain points and errors. His report feeds back into the work of the developers, who adjust the code.
User experience (UX) designer	The role of the UX designer is to make sure the product/software meets the needs and requirements of the users. To do this, the UX designer will use user personas and flow diagrams (both later described in the Lesson) to develop an app that would be relevant to users' experiences. More specifically, the UX designer will focus on the motivations, views, and values of the users to find the best solutions for the users to interact with the app. All these details are embedded in wireframes of the software that depict, in a step-by-step manner, how the user is meant to interact with the product. A simple wireframe from the Smoke Free Together app is presented below.

	
User interface (UI) designer	The job of the UI designer is to apply a visual layer over the wireframes developed by the UX designer. This person will focus on interface animation, visual elements (including the best colors to use in the app, the design), screen layout, and content. To better understand the work of the UI expert, below you can find how the wireframe previously developed by the UX expert has been enhanced by the work of the UI designer: 
End users	The users are not part of the formal software development team, but the success of the project depends on their involvement in concept design and testing, usability testing, and user acceptance testing.

3. The process of mHealth software development

Now that the roles of the software/mHealth project development team are clarified, we will focus on the process of app development.

3.1. Initial Planning and Concept Development

During the planning phase, thoroughly assess and describe the problem or health system constraint, the end-users, and the programmatic and policy context of the problem to have a firm foundation for selecting or formulating a potential mHealth solution (Matthew-Maich et al., 2016). When starting a new project, the scope of the project, the time frame, the budget, and the resources need to be considered (Davies & Mueller, 2020).

At the beginning of the design process, the capabilities, and functions that the platform must have to support the intervention need to be defined and established. Mobile devices can collect large amounts of data electronically, especially monitoring data, so ethical considerations such as data protection and usability need to be discussed (Davies & Mueller, 2020; Yanxia et al., 2020).

- Based on these requirements, determine whether open-source tools and platforms can be used. Building on existing open-source platforms can save time and expense.
- If needed, determine how the solution will link to or be compatible with the existing health information system.
- Build into the platform the capacity to collect monitoring and evaluation data, if possible.
- Assess and include any relevant regulatory frameworks and legislation to assure data protection for users.

3.1.1. Define the Problem and Ensure that mHealth is an Appropriate Solution

The first step is to make sure that the problem and context drive the solution's identification rather than the desire to use a new mobile technology tool.

- Thoroughly assess and define the problem or health system constraint and end-users or target audiences.
- Define desired outcomes and determine whether and where mobile technology could help (Matthew-Maich et al., 2016).

3.1.2. Coordinate with Programs and Health System

mHealth is a tool for strengthening health systems and achieving health objectives. Still, it might also be ineffective if it is not designed and implemented correctly or incompatible with health information systems (Matthew-Maich et al., 2016). For effective coordination and integration of interventions, thoroughly assess the end-users, the context, and the existent design methodologies capabilities (Davies & Mueller, 2020).

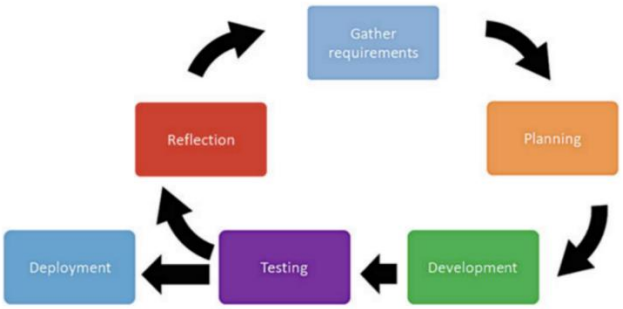
3.1.3. Assess the Context

Before selecting the software engineering methodology, a series of aspects need to be assessed:

- How end-users make use of mobile phones (or tablets) and the context in which they will utilize the mHealth solution (through formative research)
- The mHealth evidence base to identify potential mHealth solutions
- Current programs and policies related to the problem, including eHealth and mHealth programs or policies
- Mobile phone infrastructure (operators, coverage, services and fees), and potential technology partners
- Behavioral theories and frameworks related to the problem (Matthew-Maich et al., 2016)

3.2. Select the Software Engineering Methodology

The next step consists in deciding on a software engineering methodology to be employed in the development of the mHealth software. One of the most popular umbrella concept software engineering methodologies used today is the “Agile” approach (Davies & Mueller, 2020). Agile is an iterative approach that consists of gathering requirements, planning the prioritization of requirements, planning the delivery of requirements, development, testing, and deployment of small working versions of the product (minimal viable product - MVP) (Davies & Mueller, 2020).



Agile software engineering methodology (Davies & Mueller, 2020)

The Agile software engineering methodology functions on 12 principles presented below:

1. Our highest priority is to satisfy the customer through early and continuous delivery of valuable software
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale
4. Business people and developers must work together daily throughout the project
5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation
7. Working software is the primary measure of progress
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely
9. Continuous attention to technical excellence and good design enhances agility
10. Simplicity – the art of maximizing the amount of work not done is essential
11. The best architectures, requirements, and designs emerge from self-organizing teams
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly

Agile principles (Beck et al., 2001)

From the Agile approach, the two most common frameworks are Scrum and Kanban. These are detailed below.

Scrum framework is a lightweight Agile framework that "helps people, teams and organizations generate value through adaptive solutions for complex problems" (Schwaber & Sutherland, 2020).

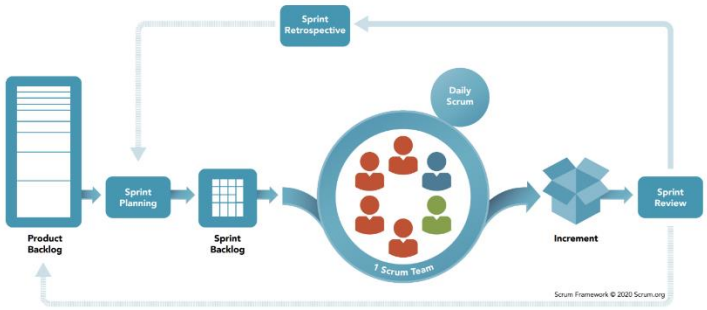
The Scrum master framework contains a Scrum master to develop an environment where:

"1. A Product Owner orders the work for a complex problem into a Product Backlog.

2. The Scrum Team turns a selection of the work into an Increment of value during a Sprint.

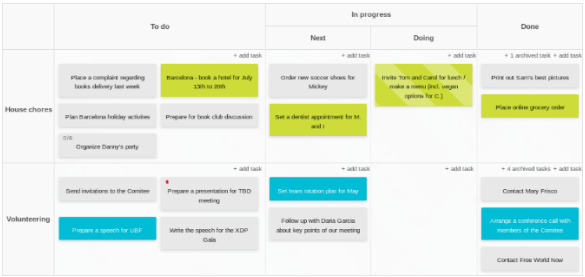
3. The Scrum Team and its stakeholders inspect the results and adjust for the next Sprint.

4. *Repeat"* (Schwaber & Sutherland, 2020)



Scrum Framework (Schwaber & Sutherland, 2020)

Kanban is another methodology from the Agile framework that "is typically a large physical board that displays the current state of work visually to offer a transparent snapshot for the entire state of the project" (Davies & Mueller, 2020). The physical board is usually split into columns with different cards that contain the working units. These units are moved between the columns to indicate the current state (e.g., from pending to progress). Kanban boards can also be developed digitally, and different softwares use this concept (e.g., Asana, Monday, ClickUp).



Basic Kanban board (Shore Labs, 2021)

3.3. Requirements gathering and presentation

After the initial planning, data for the system/mHealth app requirements needs to be gathered. Depending on the type of the project, this data can come from either the , the project team or the end-users themselves. The idea behind this step is to have a user-centred design that will allow designers to understand user requirements for all product cycle and, in the end, develop a product that offers value to the customers (Davies & Mueller, 2020). Data for system requirement can be gathered using quantitative (surveys) and qualitative tools (focus groups, interviews). This data can already be available from the sponsor or it can be collected specifically for the development of the

mHealth software. The aim is to assess users' values, needs and wants regarding the mHealth solution to be developed. For example, to build the Smoke Free Together app, the project team made use of qualitative data from 30+ semi-structured interviews and survey data collected in three different research projects spanned over 6 years and targeting smoker pregnant women (the same target population as for the Smoke Free Together app). The initial purpose of the data was not to serve as a basis for the development of the Smoke Free Together app, but the data collection instruments (questionnaires and interview guides) contained questions that were helpful in highlighting the major barriers in smoking cessation, the type of support the women needed to quit, or what expectations would they have from a potential smoking cessation app.

The data collected can be integrated and presented in many ways, including by building user stories and user personas.

3.3.1. User stories

A method for gathering data for specification requirements is to offer examples, which can take the form of user stories. User stories are beneficial in deciding and prioritizing the value of the feature included in the app. An template from Davies & Mueller of how user stories work is presented below:

As a <**type of user**> I want to <**some feature/goal**> so that <**value**>.

(Davies & Mueller, 2020)

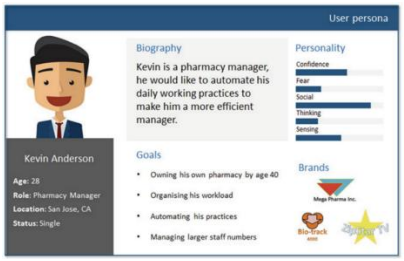
Usually, the stories that can be split into smaller stories are called *epics*, and data for the epics can be generated through different story points that take into account every user's need (Davies & Mueller, 2020). The user stories are useful because they describe the type of user for each action, the tasks and aims for each user, and what value each feature brings (Davies & Mueller, 2020).

Another example of a user story form the Smoke Free Together app is included below.

EPIC	Status Monitoring for Pregnant Smoker
USER STORIES	As a user, I am **able to**: - View my pregnancy week - Read information specific to my week **so that** I am informed about what to expect regarding my pregnancy. As a SMOKING user, I am **able to**: - View my smoking behaviour (quantity smoked, money spent) - Modify my smoking behaviour (quantity smoked, cost per smoking product) - Mark if I have quit smoking (including date and time of last cigarette smoked) **so that** I can monitor my smoking status and receive tailored information to support me quit. As a QUIT user, I am **able to**: - View my current smoking behaviour and my savings (quit date, quantity not smoked/avoided since quit date, money saved since quit date) - Modify my smoking behaviour prior to quitting (quit date & time, type of product smoked, quantity smoked, cost per smoking product) - Mark if I have relapsed smoking (including date of relapse). **so that I can** monitor my quit process, keep motivated and receive tailored information to support me quit. As a SMOKING user, I am **able to**: - View my importance, confidence, and readiness to quit smoking - Update/modify my importance, confidence, and readiness to quit smoking - View a history of how I feel (including a tailored message based on my progress) **so that** I can monitor how I feel and receive tailored information to support me quit. As a QUIT user, I am **able to**: - View my confidence in staying quit, stress level, cravings level and depression level - Update/modify my confidence in staying quit, stress level, cravings level and depression level

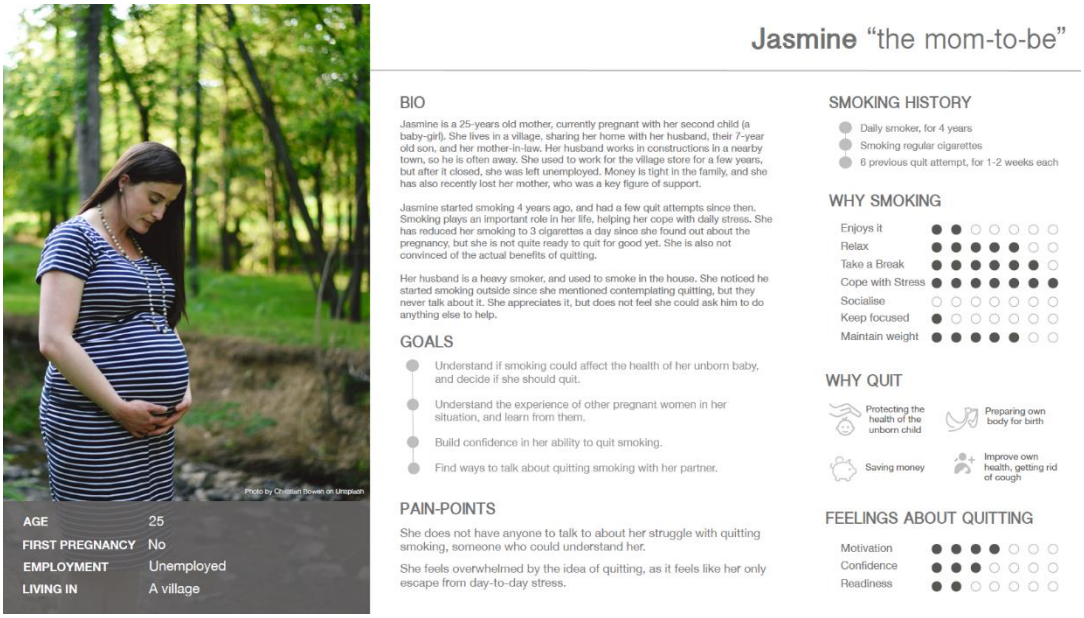
3.3.2. Personas

Another method for presenting data is using personas or stories about the user for different typologies of users of the system. These personas or stories might contain background information about the user, as shown in the example below.



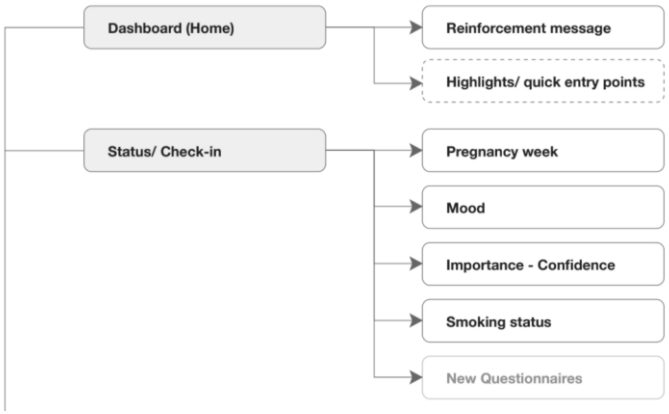
(Davies & Mueller, 2020)

The figure below depicts one of the four personas developed for the Smoke Free Together smoking cessation mobile app designed to be used by pregnant women and one nominated peer supporter of their choice.



3.3.3. Data modeling diagrams

Data modelling diagrams are used to have a better overview of the structure and flow of the application. These diagrams help in communicating the proposed system designed to the developers and stakeholders (Davies & Mueller, 2020). Data flow diagrams are one type of data modelling diagrams. These can be general, developed to provide a high-level view of the system or can be very detailed, showing how different levels of the system are structured. For example, the imagine below depicts a high-level view of the architecture of the Smoke-Free Together app.

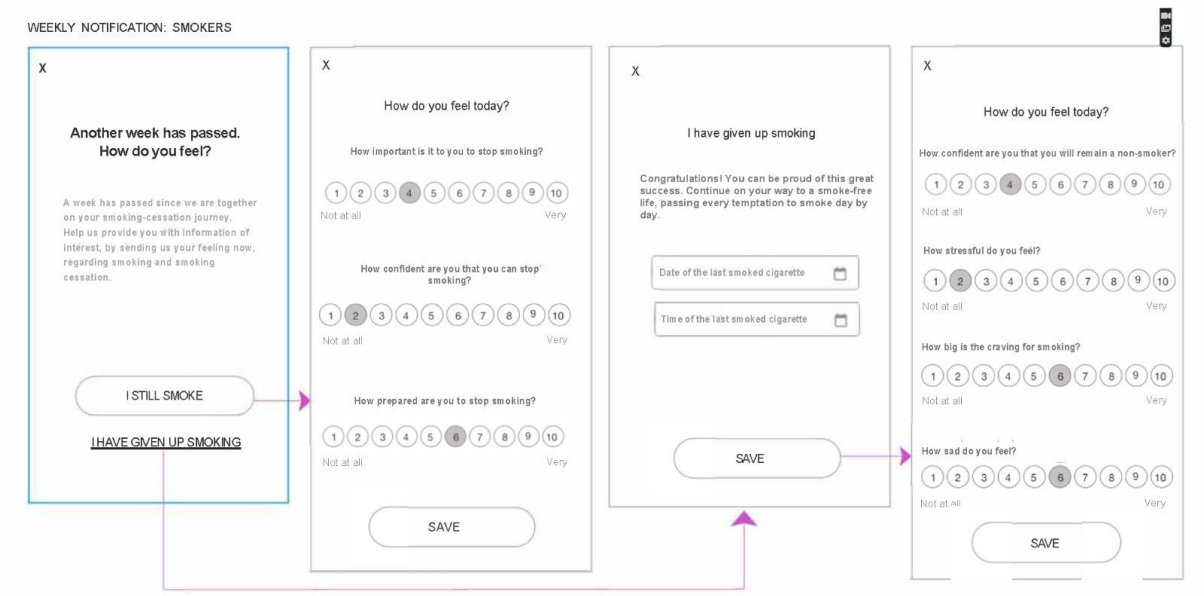


4. The phases of mHealth software development

It is important to mention that the development of an mHealth software it is not a linear process and the phases described below overlap across the app development timeline.

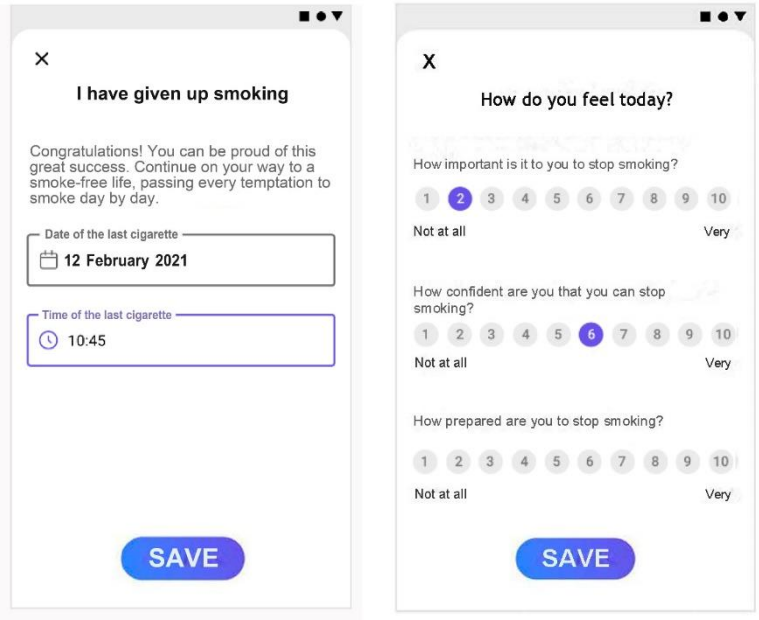
4.1. Develop app wireframes

The UX expert works with the product owner to develop the wireframes of the app based on the data gathered from the sponsor and the end users. The wireframes are usually screens from inside the app that contain the architecture and the main elements and functionalities of the app, and detail how the users are expected to interact with the app. Based on these wireframes, the technical requirements of the app are developed. Some examples of app wireframes are included below.



4.2. Designing the user interface

Use a systematic approach to design and test content and the user interface by employing User Experience (UX) testing in all stages of the product life-cycle (Davies & Mueller, 2020). If the product is designed in a way that is easy to use, enjoyable, and contains useful information, the app's uptake will be a success (Davies & Mueller, 2020). Consider rapid prototyping to design an appropriate user interface to test the product's coverage, software, and usability. (Punchoojit & Hongwarittorrn, 2017; Yanxia et al., 2020). Some examples of UI prototypes are included below:



4.3. Coding

Within the framework of the software development methodology selected by the project manager (i.e., Agile), the developers use a framework (either Scrum or Kanban) to transfer the requirements of the app into code.

4.4. Testing the mHealth software

Test message concepts, content, and user interface by using a User-Centered Design (UCD). UCD refers to "a design process whereby the users of an intended system or product are involved throughout the development processes, and the design process is centered around the needs and requirements of the end-user" (Davies & Mueller, 2020). UCD can be performed using interviews, focus groups, user stories, personas, scenarios, stories, surveys, stakeholder analysis, and any other tools that might fit usability testing needs (Davies & Mueller, 2020).

In general, three testing types are conducted. There is internal testing, conducted by the person(s) who has the tester role in the team, with the purpose to find errors in the way the software is functioning.

The second type of testing is usability testing. Usability testing can be either moderated or unmoderated and it can involve either experts in the behavior targeted by the app or end-users of the app. In moderated usability testing, users are invited to interact with the mobile app on their own mobile device, as they would in usual circumstances, by following a list of pre-defined tasks (for example, the user can be asked to find a piece of information available in the app or to change a setting in the app) and while thinking aloud. Throughout this process, the screen and the face of the users are recorded simultaneously. In unmoderated usability testing, users utilize the app independently for several days or weeks and their activity in the app is recorded with various screen recording software already embedded in the mHealth app. One such software is Smartlook, which is developed to analyze users' behaviors and generate qualitative and quantitative insights that help teams improve their products.

4.5. Project management tools

A good management tool is required for good management of the project and team working on developing the system. Different tools are used to manage and organize tasks and store the code

(these project software management tools are called version control). A selection adapted from Davies & Muellers is being offered below.

Tool name	Description	Link
Slack	Cloud based instant messaging with channels. Connects to other apps and allows file sharing	https://slack.com/intl/en-gb/
Trello	For web-based Kanban-style project boards	https://trello.com/
GitHub	Version control tools and hosting	https://github.com/
Asana	Management platform, includes lists, task board, progress tracking and calendar	https://asana.com/
TeamGantt	Online Gantt chart software	https://www.teamgantt.com/
SmartSheet	For collaborative work management. Assigns and monitors task progress, manages calendars and allows sharing of documents	https://www.smartsheet.com/
OpenProject	For project planning and scheduling and support for Kanban and Scrum	https://www.openproject.org/

Table adapted from (Davies & Mueller, 2020)

5. Additional important aspects to consider

5.1. App maintenance

A common misconception is that an app is finished after it was developed and released. However, the life of an app is an ongoing process, and maintenance needs to be considered. Each time the software receives a new update, it affects the application and intervention; therefore, constant maintenance is required. This aspect needs to be covered in the budget of the project for both money and human effort (Davies & Mueller, 2020).

5.2. The performance of the app in real-life

Once the mHealth app is finalized, in collaboration with stakeholders and partners, training and promotion plans need to be developed, and the preparations for monitoring and evaluation need to be finalized. Baseline data should be collected if required for an outcome evaluation (Yanxia et al., 2020). Essential monitoring and evaluation (M&E) tasks consist of collecting end-user feedback, summarizing system data for stakeholders, and evaluating intervention impact (Yanxia et al., 2020).

5.3. Gather Evidence that Stakeholders Need

Stakeholders often require different types of information (e.g., demonstration of acceptability, cost and cost-effectiveness, impact on health outcomes etc.). Transparent collaboration with the stakeholders from the beginning will ensure that appropriate types of evidence are obtained for M&E purposes (Yanxia et al., 2020).

5.4. Analyze and Report on System Data

Leverage the data generated by the mHealth solution (such as from system usage logs) to regularly analyze and summarize data for stakeholders (Yanxia et al., 2020).

5.5. Evaluate Project Impact

Evaluate project impact on end-users and/or the health system. Include health outcomes, gains in quality and efficiency, and cost-effectiveness as appropriate (Yanxia et al., 2020).

5.6. Consider the Potential for Scale Up

The potential for scale up of the mHealth application needs to be considered from the perspective of the end users, the perspective of the health system, and the perspective of available resourses.

5.7. The perspective of the end users. To create a scalable system, the mHealth software needs to be easy to use, acceptable and compatible with users' values and social norms. In addition, it needs to be useful to the end-users, or an improvement compared to what the end-users did or used before, such as by making their jobs easier, improving the quality of their work, saving time, or meeting clients' needs. A mHealth solution is more likely to be adopted if it is beneficial to end-

users, easy to use and minimizes costs. Additionally, if these aspects are met, some of the benefits can be provided in many ways, such as saving costs, saving time, improving quality, by meeting clients' needs, or by making it easier for health workers to do their jobs (Yanxia et al., 2020).

5.8. The perspective of the health system. The first condition that needs to be met when considering to scale up an mHealth application is the local support and buy-in for its implementation (Nouri et al., 2018; Yanxia et al., 2020). An application is more likely to be scaled up and sustained if it is linked electronically into the health ecosystem. If feasible, ensure that data collected by the solution is linked to facility-level data systems (Yanxia et al., 2020).

5.9. The perspective of the available resources. The mHealth application needs to be cost-effective to deploy and run. To the extent possible, help ensure sufficient human and technical resources for scale-up are in place. This may include advocating for supportive policies or more mobile network coverage. Essential scale-up resources include:

- Adequate mobile network coverage. You may need to adapt the solution for the existing mobile network infrastructure.
- Ongoing technical support to maintain the system and respond to problems as they arise. If the local technology partner does not have sufficient skills for implementing and maintaining the mHealth solution, it will eventually stop working. Consider mentoring them if needed to improve their skills.
- Reliable electricity for databases and monitoring dashboards in the system. How will phones or tablets be recharged?
- Secure database storage capacity, regular data back-up, and network monitoring.
- A privacy and confidentiality policy. Such a policy is needed when collecting and storing patient data (Yanxia et al., 2020).

5.10. Explore Sustainability Models or Make a Business Case for the application

Explore sustainability models or make a business case for the application.

- Identify ways that the application can help mobile operators improve their services and expand market share; use these benefits to negotiate lower rates.
- Seek financial support from public and private sources and/or end-users.

- Explore integrating mobile finance functions for sustainability.
- Explore diverse business models with partners and stakeholders (Yanxia et al., 2020).

Examples and analogies

[For each lesson plan please provide examples and analogies that show how the concept can be applied in real life, focusing on standards for quality and qualification within the two domains (IT and health and social science)]

Using the Scrum framework to develop a self-help pregnancy Android app – taken from (Davies & Mueller, 2020)
The scrum approach was used to develop an Android app to help women achieve a healthy weight during pregnancy.
Roles
The team consisted of 5 people who assumed multiple roles. The authors define the following roles:
• Product Owner: This individual acted as a liaison between the customers, the project sponsors, and the development team, and was tasked with communicating the requirements of the project
• Scrum Master: This individual was tasked with communicating the development goals to the team and with liaising between the product owners and the team. The scrum master also organised each sprint by assigning items from the product backlogs into the sprint backlogs, and assessed the team's progress at the end of each week.
• Application development team: This group was tasked with coding and testing the application.
• User interface design team: This group was in charge of designing the look and feel of each individual screen of the application.
Product backlog
The team created a product backlog detailing the required components and functionalities of the application together with the customer. This included:
• UI component: all screens and UI elements
• Notifications/reminders component: reminders for the user to input data into the app such as weight and activity
• Weight monitoring component: a feature allowing the user to input and monitor their weight over time
• Dietary information component: a feature allowing the users to input and monitor their food intake, as well as receiving feedback regarding the quality of their diet
• Activity monitoring component: a component allowing users to input and monitor their activity levels
• Google Health component: a component which interfaces with Google Health to enable the user to log weight, diet and activity information
• Feedback component: a component which provides feedback to the user based on the information they inputted
• Information library: a component containing information about food (e.g. portion sizes) and help screens
• User manual: a component providing guidance on using the application
Meetings and progress tracking
The following mechanisms were implemented to facilitate planning and progress tracking:

• Weekly meetings
• Frequent communication between individual team members via telephone to track progress • Sprint planning meetings at the start of each sprint
• Weekly meetings with the customers to assess the product backlog
Work plan and sprints
The project spanned 21 weeks, split into three sets of seven-week terms:
1. The first term involved background research and literature reviews on weight gain during pregnancy as well as requirements gathering from the customers
2. The second term focused on software development and also involved conducting focus groups to facilitate the development of front-end components. It was split into three two-week sprints: Sprint 1 focused on the user interface and the notifications/reminder component; Sprint 2 and 3 focused on the weight tracking, nutrition tracking, and the activity tracking components
3. The final term involved completing the coding of the application and polishing the user interface. This term was also split into three sprints: Sprint 1 focused on the feedback component, the Google Health component, and the information library; Sprint 2 focused on the feedback component and the information library, and Sprint 3 focused on bug fixes, polishing the user interface, and developing the user manual
The team adapted the scrum approach to suit the aims and timelines of their project. Deviations from scrum included:
• No scrum burn down chart to assess the completed work per day was created, due to limited time available to the scrum master (who was also part of the development team) and because the product backlog did not change much throughout the project
• Weekly meetings were held instead of daily standup meetings (for the same reasons outlined above)
• No sprint retrospective meetings were held due to time constraints

Using a Kanban approach in the development of a mobile app to promote a vegetarian diet - (Davies & Mueller, 2020)
A Kanban chart was used to manage the coding stage of the development of a mobile app to promote adoption of a vegetarian diet. The Kanban chart was created using Kanbanpad (a free online tool) and detailed the functional requirements of the app and tasks needed to accomplish these.
The project was managed by combining the Kanban chart with a Gantt chart. The Gantt chart provided an overview of the overall project and the higher-level tasks (e.g. “complete literature review” or “usability testing”) as well as their timelines. The Kanban chart on the other hand detailed smaller, more specific tasks (e.g. “Find studies on mobile nutrition tracking” or “Find participants for usability test”).

Example of an mHealth app – data collection examples
Radin, J. M., Steinhubl, S. R., Su, A. I., Bhargava, H., Greenberg, B., Bot, B. M., ... & Topol, E. J. (2018). The Healthy Pregnancy Research Program: transforming pregnancy research through a ResearchKit app. NPJ digital medicine, 1(1), 1-7.

NICE. (2019). Evidence standards framework for digital health technologies. https://www.nice.org.uk/Media/Default/About/what-we-do/our-programmes/evidence-standards-framework/digital-evidence-standards-framework.pdf

References for further information and areas on inquiries

[For each lesson plan please provide references and connected areas for students to further inquiry and read more about. There are 20hrs of individual work for the entire curriculum, which means 2.5 hours for each module, so 30 minutes for each lesson plan (if you decide to have 5 lesson plans).

Davies, A., & Mueller, J. (2020). *Introduction to mHealth BT - Developing Medical Apps and mHealth Interventions: A Guide for Researchers, Physicians and Informaticians* (A. Davies & J. Mueller (Eds.); pp. 1–24). Springer International Publishing. Chapters 2-8.

Yanxia, Zheng, P., Deng, H., Wang, X., Li, X., & Fu, H. (2020). Design Features for Improving Mobile Health Intervention User Engagement: Systematic Review and Thematic Analysis. J Med Internet Res 2020;22(12):E21687 Https://Www.Jmir.Org/2020/12/E21687, 22(12), e21687. https://doi.org/10.2196/21687

Lesson plan 5: Strengthening health systems using mHealth solutions

Foundational knowledge

[For each lesson plan please include a detailed explanation of the concepts, theories, models, terminology, principles, and methods being currently used related to the concept explained in this lesion plan. In doing so please create synergies within the two domains (IT and health and social science) to create mutual understanding among students]

Based on the work of the World Health Organization's mHealth Technical Evidence Review Group (mTERG), six types of applications serve as building blocks for mHealth solutions:

- Social and behavior change communication
- Workforce development
- Service delivery
- Financial transactions
- Supply management
- Information systems (Mehl & Labrique, 2014)

Social and behavior change communication

Social and behavior change communication (SBCC) applications provide health information directly to the general public and help to connect people with essential services. They also include client support for treatment adherence, such as text-message appointment reminders and support for medication adherence (Mehl & Labrique, 2014).

Workforce Development and Support

Workforce development and support applications consist of: provider training and education, supervision, work planning and scheduling and human resource management (Mehl & Labrique, 2014).

Service Delivery

Service delivery applications help support health workers' performance related to diagnosis, treatment algorithms, disease management, preventive services, and provide checklists. They include telemedicine (remote provider-client consultation) and provider-to-provider communication. An example is the mobile phone networks of health providers in Ghana, Liberia and Tanzania (set up by the non-profit organization Switchboard) that enable group members to make voice calls to each other for free or for a very low cost, facilitating consultation and knowledge sharing (Mehl & Labrique, 2014).

Financial Transactions and Incentives

Financial transactions and incentives applications help improve access to health services, reduce cash-based operating costs, and accelerate payments to providers by including savings accounts and insurance as well as performance-based incentives (Mehl & Labrique, 2014).

Supply Management

Supply management applications help track and manage supplies of medicines and other essential commodities, help prevent stock-outs and facilitate equipment maintenance (Mehl & Labrique, 2014)

Information Systems

Information systems applications include a prevalent range of activities, including data collection and reporting of patient health and service provision, registries and vital events tracking, electronic health records (EHR), and surveillance and household surveys (Global Health eLearning Center, 2013). They are meant to increase survey or patient data reporting speed and accuracy by freeing health workers and managers from cumbersome paper-based systems. Data collected on mobile devices can be fed into central servers, enabling monitoring and analysis of health systems, service delivery and disease statistics at district, state and national levels (Mehl & Labrique, 2014).

In 2016, World Health Organization's mHealth Technical Evidence Review Group (mTERG) developed the mHealth Evidence Reporting and Assessment (mERA) checklist to address gaps in the comprehensiveness and quality of reporting on the effectiveness of digital health programs. The mERA checklist aims to assist authors in reporting on digital health research, guide reviewers and policymakers in synthesizing evidence, and guide journal editors in assessing the completeness in

reporting on digital health studies. An increase in transparent and rigorous reporting can help identify research gaps and understand the effects of digital health interventions as a field of inquiry (Agarwal et al., 2017).

Examples and analogies

[For each lesson plan please provide examples and analogies that show how the concept can be applied in real life, focusing on standards for quality and qualification within the two domains (IT and health and social science)]

Social and behavior change communication

[MAYBE ADD SCREENHOTS FROM THE APPS? – DISCUSS THIS WITH EBI IN THE NEXT PHASE]

CycleTel - a text-message service piloted in India that delivers the Standard Days Method (SDM) of family planning to a user's mobile phone (Ashcroft et al., 2017).

How CycleTel works:

1. To request the service, a woman texts "JOIN" to a designated number.
2. The system asks her questions to determine eligibility to use SDM.
3. If she is eligible, the woman texts the date of her last period.
4. She then receives personalized SMS alerts on the days on which she is likely to become pregnant if she has unprotected sex (her "unsafe" days).
5. When problems or questions arise, users can call the CycleTel helpline (Ashcroft et al., 2017).

WelTel - In a randomized clinical trial known as the WelTel Kenya trial, clinic nurses in three Kenyan clinics sent weekly SMS messages to adult clients who had recently begun antiretroviral therapy (ART) (van der Kop et al., 2018).

How it worked:

1. The messages asked patients how they were doing, and patients were required to respond within two days.
2. The clinic nurses called patients who did not respond or who responded that they had a problem.

3. Patients who received the text messages had significantly higher self-reported ART adherence and improved rates of viral suppression compared to the group receiving standard care (van der Kop et al., 2018)

Workforce Development and Support

In a mHealth study conducted in Kenya, health workers in rural health facilities received daily text messages that reinforced information the health workers' had received during training. The purpose of the reminders was to improve and maintain health workers' adherence to national guidelines for the management of outpatient pediatric malaria.

Each week the health workers received 10 different messages—two messages a day, Monday through Friday. Messages reflected key recommendations from the guidelines and training manuals. Each one included an entertaining or motivating quote to make it appealing (Kaunda-Khangamwa et al., 2018).

Financial transactions and incentives

Using SMS To Reimburse Reproductive Health Service Providers:

As of March 2013, Marie Stopes Madagascar had distributed more than 29,000 subsidized vouchers in 12 rural regions of Madagascar to make it easier for very low-income clients to obtain family planning services. A voucher costs just 200 Ariary (US $0.10). A client can give the voucher to one of 143 franchised providers in exchange for family planning services that normally would cost 4,000-10,000 Ariary. Marie Stopes Madagascar uses an SMS-based money transfer system to reimburse these providers for their services (E. Burke et al., 2017).

How it works:

1. Providers send the unique code on a client's voucher by SMS to a phone number linked to Marie Stopes Madagascar's online database to receive their payment.
2. The database automatically verifies that the phone number used to send the SMS was that of a participating service provider and acknowledges that it received a valid code.
3. The system then notifies the Marie Stopes voucher manager and finance director, who checks and authorizes the codes for payment.

4. Marie Stopes Madagascar then transfers the payment to the provider using a mobile money service. The provider is notified of the payment via SMS (E. Burke et al., 2017).

Supply management:

For example, the ILS Gateway is a mobile phone-based system that supports Tanzania's Integrated Logistics System. It helps improve the availability of commodities by making facility-level logistics data more available to decision-makers. In the ILSGateway, which is active in more than 2,300 health facilities across Tanzania, staff members use their personal mobile phones to report stock levels of 20 essential family planning commodities (Sant Fruchtman et al., 2021).

Information systems

In 2011 the Nepal Demographic and Health Survey (DHS) was completed using tablet personal computers (tablet PCs) rather than paper-based questionnaires. It was the first time that mobile technology was used to conduct the DHS in Nepal. Interviewers recorded questionnaire responses directly into the tablets and submitted the data to their supervisors at the end of each day via Bluetooth. Supervisors transferred data to the main office via a mobile network (Paudel et al., 2013).

mCARE, a maternal and child health solution in Bangladesh, links community health workers and their clients (pregnant women and newborns).The goal of mCARE is to improve pregnancy registration and support the survival of preterm infants (Jo et al., 2019). The mCARE health information system uses several applications that support or provide:

- Pregnancy surveillance and registration
- Scheduling and delivery of antenatal and postnatal care
- Automated reminders for antenatal and postnatal visits
- Home-based newborn care checklists
- Labor and birth notification
- Referral and emergency mobilization (Jo et al., 2019)

mCARE blends information systems (surveillance and registration), workforce development (scheduling), SBCC (automated reminders), and service delivery (checklists, notifications, referral) applications (Jo et al., 2019).

References for further information and areas on inquiries

[For each lesson plan please provide references and connected areas for students to further inquiry and read more about. There are 20hrs of individual work for the entire curriculum, which means 2.5 hours for each module, so 30 minutes for each lesson plan (if you decide to have 5 lesson plans). Books, scientific publications, and other activities connected with the topic of the modules can be offered as references in this section]

Example of mHealth apps:

1. https://mhealthintelligence.com/news/digital-cds-in-action-4-examples-of-mhealth-at-work

2. https://www.businessinsider.com/mhealth-apps-definition-examples .

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4. Appendices

[In the appendix, it can be useful to share your sources and list the documents used as in a bibliography. Please cite any information sources using the APA citation style]

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