Building bridges for meaningful ehealth: aligning people, technology and practice through collaboration and knowledge sharing

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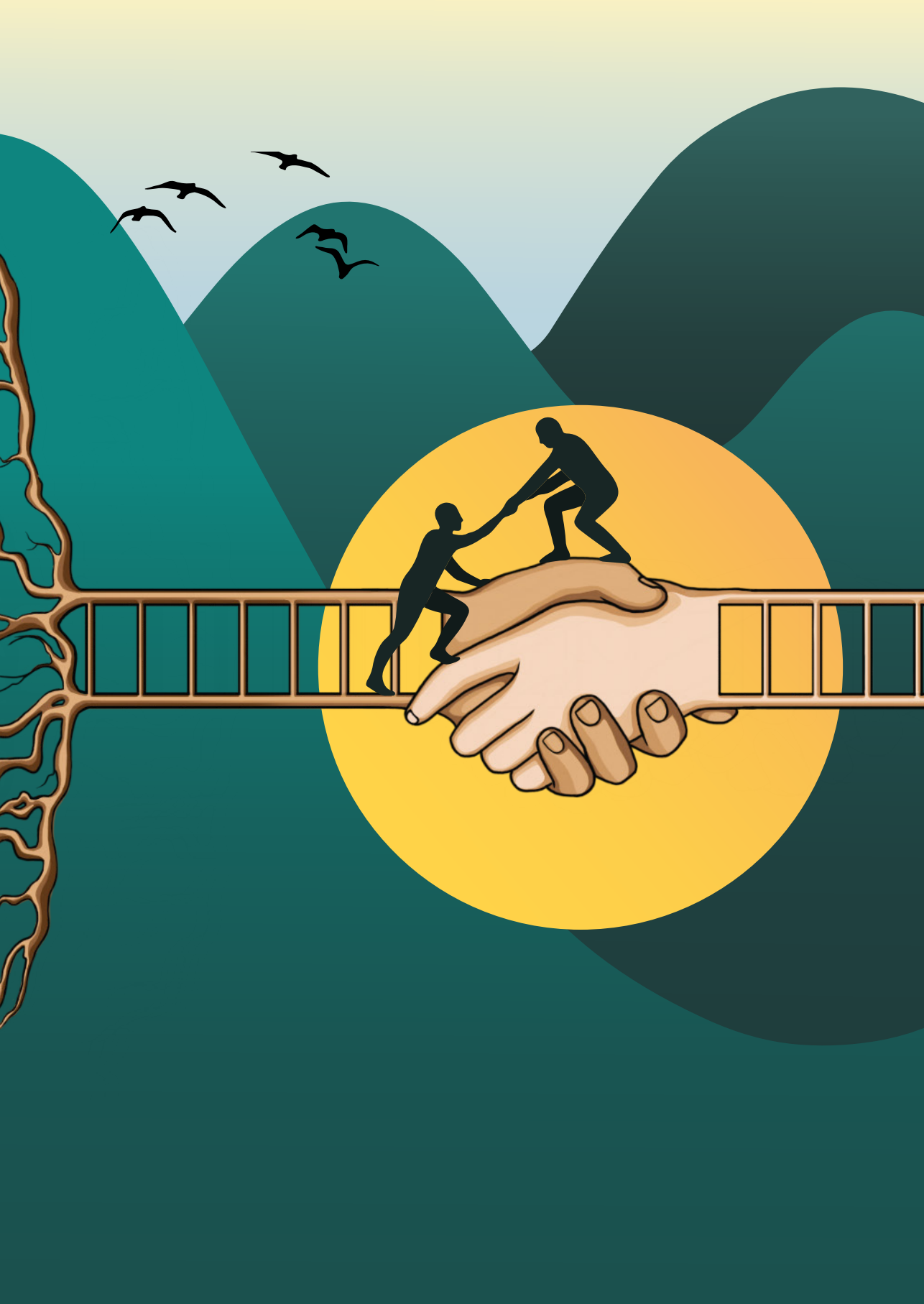
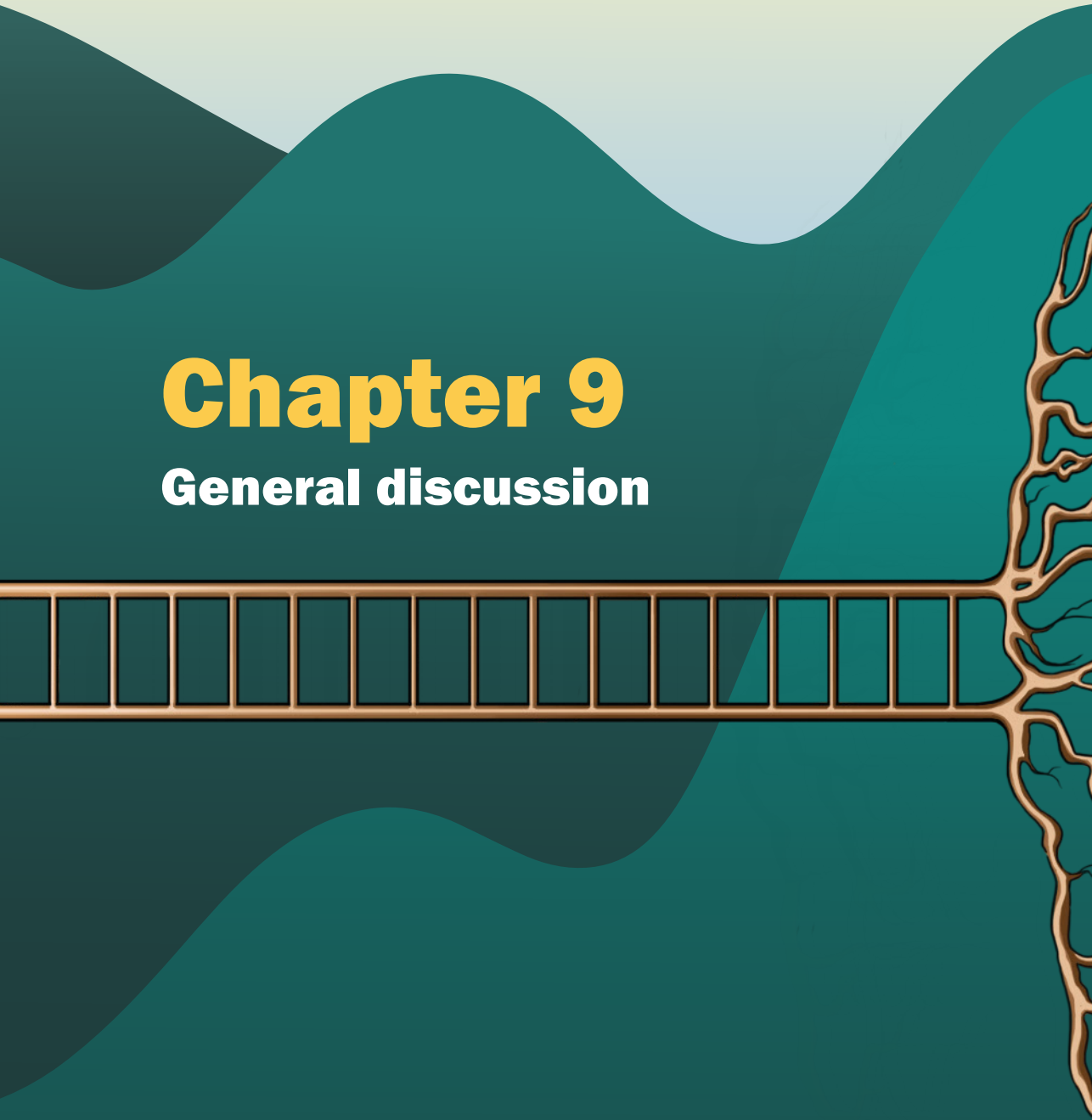


Chapter 9

General discussion



General discussion

In accordance with the adage, "with the wisdom of hindsight", a consistent observation emerges: embarking on the same journey for a second time is invariably easier. This dissertation encompasses a collection of distinct studies, each presenting a unique journey, involving different contexts, disciplines, approaches, and methodologies. While some journeys were pre-defined, others were discovered along the way, making this dissertation a co-production between different disciplines, following different paths, and offering different perspectives. As such, our journey has yielded several new insights and helped us gain new knowledge along the way. Knowledge and insights that reinforce our decisions made and provide alternative perspectives when considering the broad context of eHealth development, evaluation, implementation, and sustainment.

This closing chapter serves as a reflection on the road travelled, the knowledge acquired along the way and the lessons learned by embarking on this journey with designers, behavioural change experts, persuasive game design experts, various healthcare developers, patient advocates, app developers and statistical advisors. Drawing inspiration from the words "the journey matters more than the destination" we believe that these journeys were necessary to acquire these lessons on development, evaluation, and implementation of eHealth. The lessons learned tap into the five challenges presented in the introduction, thereby offering a wider perspective on the intricate relationship between patient empowerment and eHealth literacy, meaningful patient and public involvement, the road toward sustainable implementation, the challenges and implication of evaluation of eHealth and the importance of creating a favourable academic climate in creating societal impact with eHealth. These lessons learned have been clustered into five themes, each of which concludes with key messages intended for fellow (prospective) eHealth researchers, healthcare professionals and academic institutions who play a vital role as knowledge brokers in the field of knowledge dissemination.

THEME 1 – SELF MANAGEMENT, PATIENT EMPOWERMENT AND eHEALTH LITERACY

Within the ongoing transformation and digitalisation of healthcare in the Netherlands, people are expected to participate in and take responsibility for their own health (1). This entails fostering shared decision making and empowering patients to participate in their healthcare choices (2). Patient empowerment focuses on increasing a patient's capacity to think critically and make autonomous, informed decisions about their health and has been associated with improved health outcomes, greater healthcare satisfaction, better treatment adherence and reduced healthcare costs (3, 4). This is particularly of importance for individuals with chronic conditions, who continuously self-manage their health regardless of their interaction with the healthcare system or specific professionals (5). Recognizing the significance of patient empowerment and self-management, numerous eHealth interventions for chronic diseases, such as asthma and COPD, focus on empowering patients to enhance their self-management

skills (6, 7).

However, it is essential to acknowledge that in this digital era patient empowerment must be accompanied by adequate health and eHealth literacy to enable individuals to make well-informed decisions (6). Patients who possess a high degree of empowerment but lack adequate health or eHealth literacy may make risky health choices, leading to adverse outcomes and increased healthcare costs (8). For instance, a patient with asthma monitoring their lung function using a peak flow meter to self-monitor might decide to use their reliever medication when their peak flow values are low. While this decision reflects patient empowerment, the patient may lack understanding of the distinction between a reliever and a maintenance inhaler, potentially causing harm in the long run (8).

We integrated empowerment principles in the design of the persuasive game 'Ademgenoot' to support people with asthma in their medication adherence, alongside patient education on the difference between maintenance and reliever inhaler (**chapter 2**). We applied personal goal attainment in combination with a behaviour feedback mechanism to motivate patients to adhere to their maintenance inhaler and thereby empower them in doing so. In **chapter 3** we focused on people with asthma and limited health literacy, to improve their understanding and organization of medication intake by visualizing the medication's effects on the body and the relationship between usage and symptoms.

Hence, eHealth interventions should incorporate principles of empowerment, but at that same time be mindful of differences in health and eHealth literacy that enable people to make well-informed and reasoned choices. In **chapter 7**, we adapted a widely used instrument for measuring eHealth literacy to the Dutch context, providing a valuable tool for understanding users' eHealth literacy needs in the design, development, and evaluation of eHealth solutions (**Challenge one, General introduction**). Also in our design research for people with asthma and limited health literacy (**chapter 3**), we were mindful of their eHealth literacy needs, as people with limited health literacy generally have little experience with digital health technologies and services (9). We carefully addressed their eHealth literacy needs through co-constructing stories, experience prototyping, and utilizing simplified visuals and illustrations to explain complex physiological processes in the final prototype of the app.

In summary, while patient empowerment and the use of eHealth to support self-management have the potential to improve health outcomes and reduce healthcare costs, it is crucial to be mindful of individuals' health and eHealth literacy needs. Tools like the eHLQ can help identify eHealth literacy needs and provide tailored support to individuals with limited eHealth literacy. This support can include training and education to enhance eHealth literacy, assistance from healthcare professionals in effectively utilizing eHealth resources, technology-enabled learning experiences (e.g., an interactive game used to teach people to navigate a patient portal) and involving individuals with limited eHealth literacy in the development of eHealth solutions.

TAKE HOME MESSAGES | THEME 1

- Patient empowerment has the potential to improve health outcomes and increase patient satisfaction. However, it must be accompanied by sufficient health literacy to ensure informed decision-making. Lack of health or eHealth literacy can lead to risky choices and negative outcomes, despite patient empowerment.
- While eHealth has the potential to empower people in self-managing their disease, digital health technologies or services should fit people's eHealth literacy needs.
- The eHLQ Dutch version can be a useful tool to understand the eHealth literacy needs of people in a Dutch healthcare or research setting and guide the design, development, and evaluation of eHealth solutions.

THEME 2 - MEANINGFUL INVOLVEMENT OF END-USERS AND THE PUBLIC

The continuously evolving digital landscape has led to the general consensus among academics and health innovators that involving end-users should be standard practice in the development and evaluation of eHealth solutions (10). This agreement is rooted in the understanding that solutions are more likely to meet end-users' needs and benefit them when they are actively involved in the design process. Meaningful involvement, however, requires that end-users are able to articulate their needs. A seemingly logical requirement, but one that is often overlooked by medical and healthcare researchers, and prompted the question: "how can we help people articulate their needs?" (**Challenge one, General introduction**).

How can we reveal the deeper levels of knowledge?

In current healthcare research and intervention design, medical researchers often rely on qualitative methods such as interviews of focus groups discussions to identify end-users' needs. Qualitative researchers are generally trained to be good observers and listeners. They interpret what is being said or what they observe into what it means. However, their source of data strongly depends on how well people can articulate themselves or verbalise their needs, or the observation of behaviour at the specific moment in time. As mentioned in the beginning of this dissertation, needs, motivations and desires are often concealed in deeper knowledge layers. Knowledge that people can act upon but not readily express in words (tacit knowledge) and knowledge people are not aware of yet (latent knowledge). These types of knowledge do not necessarily manifest themselves in the present in order to be observed (11). However, these deeper knowledge layers can be revealed using participatory design methods (12, 13) .

This dissertation (**chapters 2,3 and 4**) exemplified various approaches to using participatory design methods. It demonstrated how design and creative practices can help people articulate their needs, thereby granting them a voice in the design

process. In **chapter 2**, participatory design methods were employed to elicit the needs of people with asthma, which led to the design of a persuasive game to motivate individuals with mild asthma to adhere to their maintenance medication (**Challenge two, General introduction**). In **chapter 3**, people with limited health literacy were actively involved, and participatory design tools helped to gain an understanding of their specific needs and preferences. Lastly, **chapter 4** demonstrated how participatory design can be used to include children in the design of an app to reduce pre-procedural stress and anxiety.

Given the enormous possibilities of participatory design tools and techniques, selection and tailoring of participatory design tools and techniques is a delicate process and should be based on 1) the purpose and 2) the context in which they are utilized (14). Purpose can be priming participants (i.e. immersing participants in the domain of interest), probing (i.e. revealing participants personal perspectives), understanding or generating ideas or design concepts (12, 14). Context can be described along the four dimensions: group size, group composition, face-to-face versus online, venue in which the participator design activity is held, and stakeholder relationship (14).

In this dissertation we carefully selected and applied participatory design tools that aligned with the purpose and context of their usage, customizing them accordingly. To prime participants we developed an introduction video featuring the design researcher himself (**chapter 3**) and providing sensitizing materials to stimulate self-reflection and collection of lived experiences on dealing with asthma (**chapter 2**). To gain an understanding of end-users' needs, experiences, and motives we used personas (**chapter 2 and 3**), co-creating stories (**chapter 3**) and experience journey mapping (**chapter 4**). To generate new ideas or design concepts, we employed paper-prototypes (**chapter 2 and 4**), think aloud exercises and mock-up or clickable prototypes (**chapter 2, 3 and 4**). Throughout all projects, we opted for a face-to-face approach, selected home environments as the preferred venue, and carefully managed stakeholder-participant relationships, incorporating a trust officer (**chapter 3**) or parents (**chapter 4**).

Furthermore, we made a deliberate effort to tailor our participatory design tools to accommodate the characteristics of the end-users, consider their cognitive abilities, communication skills, and any potential barriers they may face regarding participation (e.g., risk of stigmatization, mistrust, financial barriers). This is especially important when including people who can be considered vulnerable or have difficulties verbalizing their needs, such as those with limited health literacy (**Challenge three, General introduction**). People with limited health literacy may struggle with abstract thinking or understanding the content of the study, may experience language or literacy problems or feelings of anxiety towards research or the research team.

In **Chapter 3,** we demonstrated the active involvement of individuals with limited health literacy in participatory design. Through the careful selection and tailoring of appropriate participatory design tools and techniques, we effectively engaged these individuals and fostered mutual understanding during the research process. The

utilization of the co-creating stories method enabled individuals with limited health literacy and asthma to reflect upon their experiences with adhering to their asthma medication regimen. By using relatable fictional stories, participants were able to share their own experiences, connect with different characters, and contemplate their own behaviour and motivations for non-adherence. Experience prototype sessions, involving physical interaction with multiple prototypes, further facilitated the expression of preferences, needs, and attitudes toward the prototypes by end-users. Similarly, the design process involving children (**chapter 4**) necessitated the customization of participatory design tools. To address children's difficulty in envisioning the final product, visual elements, such as a colourful animal theme, were incorporated into the prototype and a hospital setting was simulated.

While the toolbox for participatory design offers an extensive array of tools and techniques, it is not practical nor comprehensive to provide a complete repertoire in this dissertation. Nonetheless, the studies in this dissertation successfully illustrate several ways in which participatory design tools can be effectively employed for different purposes, within diverse contexts, and involving a range of end-users thereby adding to the knowledge base on the use and application of participatory design tools and methods in eHealth design.

Prerequisites for meaningful end-user involvement in design

The active involvement of end-users and granting them a voice in the development and evaluation of eHealth solutions, are not only crucial for increasing the likelihood of successful adoption but also aligns with ethical principles of justice and inclusiveness. It is our ethical responsibility to value individuals' lived experiences, listen to their narratives and involve them in the design process. Also from a societal stance, it can be considered a human right for those affected by the digital transformation now and in the future to have a say in the design solution to the complex issues and societal challenges that awaits us. Consequently, we are obligated to make every effort to include individuals and communities most in need, ensuring that eHealth solutions benefit everyone and do not contribute to widening the digital divide (**Challenge three, General introduction**).

In **chapter 3** we concentrated on how to involve people with limited health literacy in the design of eHealth interventions and give them a voice. However, meaningful involvement of people with limited health literacy or lower socio-economic position requires also other important consideration to assure meaningful involvement. Several of these considerations have also been described in the context of including socio-economically disadvantaged population as study participants in randomized controlled trials (15, 16).

Firstly, research should be planned and structured in a manner that accommodates the needs of the participants, such as employing a flexible study design and considering participants' competing demands like childcare or other family responsibilities. In the eHLQ translation study (**chapter 7**) we included recruitment with posters at various familiar (public) spaces such as sport clubs and community centres to reach

more socio-economically disadvantaged individuals. In the ACCEPTANCE study protocol, we included follow-up telephone calls by the patient's general practice as a recruitment strategy, to minimize the risk of including only those with controlled asthma en generally more willing to participate in clinical trials (**chapter 5**).

Secondly, maintaining a collaborative team is crucial to foster and ensure effective communication (17). This can be achieved through regular communication with participants, having a familiar point of contact (e.g., a research assistant performing all study activities, **chapter 5**) and by providing transparency in design decisions. The design researcher (**chapter 3**) visited a community centre multiple times to first build trust before inviting people to participate in the study. People who were invited by their practice nurse to participate received a video with the design researcher introducing himself and explain in plain terms the purpose and set-up of the study activity. This helped establish familiarity and build trust (**chapter 3**).

Lastly, it is important to take into account potential socio-economic barriers such as lack of transportation, financial constraints or limited access to healthcare facilities (15). We accommodated for this by performing the study activities at people's houses (**chapter 5 and 7**) or at the neighbourhood's community centre (**chapter 3, chapter 5, and chapter 7**), or by providing a financial compensation when study budget allowed it (**chapter 5 and chapter 7**). Thus, before embarking on a journey including socio-economically disadvantaged people as study participants or as active contributors, researchers should invest time, budget, and effort in establishing a meaningful collaboration and trust. Throughout the process, it is essential to report on and reflect upon the execution, documenting best practices and lessons learned. By doing so, we can ensure that eHealth solutions are designed with the needs and preferences of those who would benefit the most in mind and are evaluated with them. This is a vital step in working towards an equitable and inclusive digital health landscape, reducing health disparities, and improving health outcomes (**Challenge Three, General introduction**).

Creating meaningful patient and public involvement

Besides meaningful involvement of people in the design of eHealth, the importance of the involvement of patients (and public) in the set-up and execution of clinical research has become increasingly evident in the past two decades (18). This is reflected by the growing body of evidence on its value, the publication of guidelines on patient and public involvement (PPI), reporting standards and the inclusion of PPI as requirements by funding bodies and journals (19, 20).

In our cluster RCT evaluating the effectiveness of an asthma inhaler programme (**chapter 5**), we established a patient advisory panel to provide input throughout the research process. Recognizing the novelty and complexity of the intervention, involving patients was crucial. The patient advisors provided valuable insights into study design, materials, and feasibility. They also contributed to improving communication, recruitment (e.g., through social media), and retention strategies. By involving patient advisors from the early stages, setting clear expectations, defining

their roles, and maintaining regular communication and evaluation, we established a mutually beneficial collaboration. Our experiences were compiled into a short video in collaboration with a leading patient involvement institute, which is now used for researcher training.

Throughout this dissertation, we actively engaged individuals in various aspects, whether in the design of new concepts or the design and execution of clinical effectiveness studies. We witnessed first-hand the value it brings to research. Consequently, we identified six questions that eHealth researchers should consider to attain meaningful involvement of patients or individuals and its relevance to the research as a whole (see Box 1). While addressing all questions in detail goes beyond the scope of this dissertation, we encourage eHealth researchers to carefully consider these aspects and set-up a plan accordingly, before engaging in PPI or participatory design.

Box 1. Six questions researchers should ask themselves to achieve meaningful patient and public involvement (PPI) in eHealth research

1.	In which phase of the eHealth evaluation cycle is our project?
2.	Who is our target population (e.g., end-user, individuals that would benefit from the studied intervention?)
3.	What do we aim to achieve with PPI (i.e., identify specific needs, understand lived experiences for design purposes)?
4.	How will we implement PPI (e.g., what participatory design or PPI tools to use)?
5.	What are possible conditions and challenges (e.g., planning, funding)?
6.	How will we evaluate the impact of PPI on the project?

Lastly, we emphasize the importance of reporting best practices in research. Clear reporting guidelines with standardized approaches for reporting and reflecting on strategies to include and involve people, patients, and the public facilitates an understanding of good practices. The reporting should include how people were involved in the research, a detailed description of their roles in each phase, the participatory design of PPI tools, techniques, and methods used to elicit their needs, values, and preferences, a description of the study setting and how certain barriers were accommodated for (15). Most importantly, it should highlight what worked and what did not, serving as a guidepost for future research endeavours.

‘Users are experts of their own experience; designers are experts of the innovation process’

End-user involvement is crucial for participatory design, but the involvement of designers is equally important. This dissertation includes three participatory design projects (**Chapter 2, 3, and 4**), all of which were conducted in close collaboration with designers, without whom they would not have been possible. While users are experts in their own experiences, designers are experts in the innovation and design process. They possess a wide range of skills that are invaluable to healthcare innovation,

including problem understanding and identification, empathizing with users, clear and effective communication of ideas and concepts, and creative thinking focused on the "why" and "how" of solutions.

However, collaboration between two distinct disciplines—medical research and design research—brings its own challenges. Groeneveld et al. identified several challenges that designers face when working in healthcare (21). These challenges stem from the relative unfamiliarity of design research within healthcare research and the medical research culture, which may not always be favourable for the fast-paced, iterative, and flexible design process.

As such, collaborating effectively with designers in healthcare requires establishing mutual understandings as the foundation for collaboration. First, both disciplines need to communicate and understand each other's standards. For example, healthcare researchers should inform designers about the need to obtain medical ethical clearance early in the process, while designers should communicate the iterative nature of the design process and its associated phases (22). Second, both parties should be aware of the regulated environment in which research takes place, which allows little room for improvisation. Establishing contact with patients directly within healthcare settings, without the involvement of treating physicians, can be challenging due to the inherent patient-physician relationship. To overcome this, we recruited people with asthma outside of healthcare clinics (**Chapter 2**) and utilized social media channels (**Chapter 2, Chapter 5).** Third, both parties should clearly communicate their expectations regarding the outcomes of the design project, which may not be always a ready to be implemented end-product, from the outset. This begins with understanding the value of the design process as a whole.

While presented as distinct challenges, they are all interconnected, stemming from a lack of mutual understanding. Therefore, prior to embarking on a design journey, designers and healthcare researchers and professionals involved should invest time and effort to learn each other's language, involve academics with experience in both design and medical research, understand the research context and appreciate the value that participatory design brings to the project.

Changes in clinical ethics approval and governance

To foster a more favourable research environment for participatory design institutional changes are necessary, particularly in clinical ethics approval and governance. Current medical ethical approval practices in the Netherlands primarily focus on 1) the protection of the autonomy and rights of individuals participating in clinical research and 2) the pre-specified study protocols and other documents to assess the potential harm to the participants (23, 24). This approach ensures that studies such as our cluster RCT **(chapter 5)** and the RCTs included in our Cochrane Review (**chapter 6**) are conducted in a way that is ethical, safe, reproducible and protects the rights and welfare of the participants. However, this linear approach in which people are considered as subjects on whom research is done and should be protected, is in stark contrast with the co-creative and iterative approach of

participatory design in which people's lived experience, expertise and personal perspective are considered as a source of knowledge which informs the next design steps and for which reciprocity and equal power between researcher and participant is required (25). Consequently, definitions of 'benefits and risks' differ between a classical medical and participatory design viewpoint. Participatory design approaches 'benefits' as a right to have a seat at the table and ensure a fair chance to participate and 'risk' of not being able to participate. Conversely, classical medical viewpoints perceive study procedures as potentially harmful to an individual (25). Hence, for participatory design to benefit healthcare, clinical ethics approval should provide room for adaptation, facilitating a fast-paced and iterative process of data collection, analysis, and reflection. Thus, medical ethical review approvals should establish the framework within which participatory design research can be performed, leaving sufficient room for flexibility, deviations from initial plans and adaptation of study methods and procedures to benefit the overall objective. Essentially, this would broaden the view on 'participants' from an individual on whom research is 'done', to an individual who is actively engaged in designing and implementing the research or design process. We believe that this viewpoint benefits the individuals involved, enhances the socio-cultural movement of involving patients in clinical research, and promotes empowerment and ownership, an essential aspect of modern healthcare.

To bring about changes in clinical ethics approval and governance, ethical principles of respect for persons, risk and harms should be evaluated in a new light. As such, we echo Goodyear's words and encourage medical ethical committees to acknowledge and embrace the diversity of research (22). This can be achieved by training ethics board members on various research study designs, including professional expertise in the review process, fostering discussions and debates among review boards, researchers, and research participants, and helping board members understand the empowering and reciprocal relationship between researchers and the people involved (22, 25).

TAKE HOME MESSAGES | THEME 2

- Healthcare researchers have a responsibility to do their absolute best to help end-users to articulate their needs. These often reside in the deeper layers of knowledge. This means going beyond the traditional methods of interviews and observations.
- Participatory design methods and tools are useful methods to reveal deeper layers of knowledge and help people articulate their needs. Researchers should decide on what tools and techniques to use based on the purpose and the context and tailored to fit the target population.
- Meaningful involvement requires accommodating the characteristics and potential barriers of participants, especially those with limited health literacy or difficulties verbalizing their needs.

TAKE HOME MESSAGES | THEME 2 (Continued)

- Multidisciplinary collaborations between medical researchers and designers requires both parties to invest time and effort to learn each other's language, the healthcare context in which the research is performed, and the value of design and its process.

- The governance and protocols of medical ethical committees are not favourable for participatory design research projects as these are based on a linear approach, require pre-specification of study procedures and documents, and consider people solely as participants that can be harmed by research activities.

THEME 3 –IMPORTANCE OF CREATING VALUE FOR ALL STAKEHOLDERS FOR SUSTAINABLE IMPLEMENTATION

The importance of involving other stakeholders, such as various healthcare professionals, in eHealth design is also becoming more evident (26). Especially considering the fact that current healthcare problems often involve complex and interconnected challenges, known as "wicked problems," which are characterised by stakeholders having additional needs or conflicting needs compared to end users. Stakeholder involvement ensures that the intervention aligns with the existing work processes and thinking of those who will interact with the technology or health service, or in another way will experience impact of the intervention on themselves or their work. For example, nurses should incorporate the Hospital Hero animals (**chapter 4**) in their interaction with children to create an immersive safari experience. Additionally, involving developers, such as those working on smart asthma inhaler programs, is necessary to align with their business strategy (**chapter 2**).

To facilitate effective stakeholder involvement, the first step is to identify all relevant stakeholders. Tools like stakeholder identification and analysis and stakeholder mapping (27) help identify all individuals affected by a given technology, their responsibilities, interdependencies and what is at stake for whom (28). Second, the needs of stakeholders should be identified. This can be achieved by involving them directly in the participatory design activities such as experience journey mapping sessions (**chapter 4**) or through separate meetings to discuss insights, align thoughts and plan subsequent steps collaboratively (**chapter 2**)**.** Strategies like prototyping can be employed to communicate early ideas and identify areas of agreement and disagreement.

Besides identification and prioritisation of all stakeholders' needs, early stakeholder involvement is important for implementation. Stakeholders play an important and often influential role in the decision-making process, particularly in the context of purchasing decisions (29). Moreover, when stakeholders perceive that their input has been heard and incorporated into the design, they are more likely to support the innovation and advocate for its adoption (30, 31). As such, late or no stakeholder involvement has been found to form a barrier for the uptake and implementation of digital health interventions (31, 32). Throughout our research, we strived to involve

various stakeholders and capture their needs through participatory design activities, such as experience journey sessions (**chapter 4**), structured brainstorm sessions, prototyping, simulations, and visualizations (**chapters 3 and 4**). While we mainly involved internal stakeholders (i.e. individuals directly involved in the development or implementation in daily practice) it is equally important to include external stakeholders such as top-management as they play a relevant role in supporting the innovation process, championing it and protecting it from short-term pressures (32, 33).

When involving stakeholders, it is important to recognize that development and implementation of eHealth is an ongoing journey, wherein the value of these technologies for each stakeholder within their specific usage context needs to be understood. Stakeholder can be involved in different phases accordingly. This entails involving internal stakeholders, such as healthcare professionals and developers, earlier in the process, while engaging external stakeholders such as decision makers, regulators, financiers, and suppliers later on when addressing issues like feasibility, sustainability, and cost-benefit (27).

The importance of early business development exploration

Besides implementation challenges caused by lack of early stakeholder involvement, large scale implementation of eHealth faces challenges related to funding, uncertainties regarding effectiveness and scalability (**Challenge four, General introduction**). Unfortunately, the majority of all eHealth initiatives fail to reach the implementation and scale-up phase and stop when project or research subsidies have dried up (34).

To mitigate the risk of implementation failure, it is crucial to define a suitable implementation strategy as an integral part of the eHealth development process. One critical aspect of the strategy is defining who will pay for the eHealth technology or service. Currently, many innovations fail to scale-up because of the inability to find a sustainable funding model (35). This is of particular concern in innovating within the Dutch healthcare system (in which all studies described in **chapters 2 till 4** were conducted) as the end-users are rarely the payers. Instead, healthcare insurance companies, healthcare institutions or hospitals bear the costs. Therefore, for an eHealth technology or service to succeed, it must bring value to the payer. In other words, the payer should in some way benefit from the technology. This can be achieved as the technology reduces costs, improves workflow efficiency, or enhances healthcare and employee satisfaction. It is important to note that an eHealth technology that meets the needs of end-users (e.g., patients) does not necessarily guarantee willingness to pay from the intended payer (e.g., insurance companies, hospital boards).

The CeHRes roadmap can be a valuable tool in addressing these considerations early in the development process. It takes a holistic approach by integrating eHealth design with implementation and business development frameworks. By addressing questions about the value created by the technology and who benefits from it, the

roadmap ensures a better fit among humans (meeting their needs), organizations (aligning with their digital strategy), and technology (being technically feasible and compatible with existing infrastructure). It emphasizes a value-driven approach and considers the needs of all stakeholders (36). Currently, development teams often define the value proposition and business model post-development, rather than integrating them into the development process. However, having the potential payers involved from the start can help co-create value to the eHealth technology and inform the business model (27), which is necessary for adoption and sustained funding (37).

Therefore, we recommend that researchers adopt frameworks like the CeHRes roadmap to systematically identify all relevant stakeholders, understand their needs, explore value propositions, and actively incorporate business modelling in the development and implementation process. While defining a business case or launching a business is generally not considered a primary focus for academics, start-up incubator programs can provide university spin-offs with the necessary resources, support, and guidance to establish themselves a business and gain traction in the market, moving beyond project funding. Although beyond the scope of this dissertation, paediatric nurse Nicole Donkel and myself decided to spin-off the Hospital Hero app (**chapter 4**) and participate in an incubator program for start-up companies after its development. This program offered us valuable insights for defining our business case and advancing the implementation and scale-up of the Hospital Hero app.

Lastly, both public and private funding bodies play significant roles in catalysing the development and implementation of eHealth solutions. However, few public and private funding parties provide specific funding for activities such as market or business validation. Funding opportunities that do encourage for example stakeholder identification and analysis are still outcome driven, requiring a finished product as output, making value identification a secondary objective. The complex system of payments or reimbursements, typically coming from third parties like the government or private insurance companies, further complicates funding issues (35). Moreover, there are differences in perception of value, financial incentives and the intricate interplay between economics of insurers and healthcare providers to consider (38).

TAKE HOME MESSAGES | THEME 3

- Stakeholders, such as healthcare professionals and developers, and their needs should be identified and considered early in the eHealth development process, in order to ensure that the intervention aligns with existing work processes and thinking, and to support its implementation.
- Incorporating business development exploration early in the eHealth development process is crucial for finding sustainable funding models, addressing implementation challenges, and ensuring the technology brings value to payers and other stakeholders.
- The CeHRes framework can be used to identify and address questions on implementation, value proposition and the underlying business case early in the process.
- Funding bodies can facilitate sustainable implementation by providing funding schemes aimed at validating the business model and investigating commercial feasibility.

THEME 4 – SUMMATIVE AND FORMATIVE EVALUATION OF EHEALTH

In previous themes we focused on the development process of eHealth and emphasized the importance of involving end-users and stakeholders in the developmental process of eHealth. In the following theme we address the need for proper evaluation, present various evaluation methodologies, and discuss the challenges associated with applying traditional research designs like RCT and meta-analysis in the context of eHealth (**Challenge Four, General introduction**).

This dissertation includes several eHealth evaluation studies that employ different methodologies based on what is being evaluated and the purpose of the evaluation (39). Evaluation can be categorized into three types: process evaluation, impact evaluation and outcome evaluation (39). In **chapter 2 and 3** we performed multiple small scale evaluation studies (process evaluation) to assess whether the prototype of the eHealth solution met the design requirements (e.g., does the design visualise the effect of inhaler use in a compelling way? Does the participant feel motivated to perform the desired behaviour?). Based on the findings, adjustments were made to improve the design. In **chapter 4** we performed a pilot study (impact evaluation) to assess the Hospital Hero app on use, user-experience, and usability. **Chapter 5** presented a study protocol for evaluating a smart asthma inhaler program, focusing on multiple clinical and patient outcomes (outcome evaluation), while in **chapter 6** we performed a meta-analysis to examine the overall effect of different integrated disease management programs, including eHealth-based programs, on clinical outcomes (outcome evaluation).

Clearly, the evaluation studies had different objectives. **Chapter 2, 3 and 4** aimed to gain understanding of user experience and user-interactions with the digital health technology to inform design improvements and implementation. This type

of evaluation, known as formative evaluation, draws its roots from educational assessment where it is used to assess students' learning process and to adjust learning and teaching practices accordingly, rather than solely judging students' performance. In the development of eHealth, formative evaluation, which involves continuous evaluation, adaptation, and re-evaluation, plays a central role. On the other hand, summative evaluation aims to assess whether the desired endpoints have been reached. In educational assessment, it would determine whether students pass the test. The cluster RCT ACCEPTANCE protocol in **chapter 5** is a form of summative evaluation, aimed at investigating the effectiveness of a smart inhaler asthma self-management programme on medication adherence and clinical outcomes. By also assessing usability, acceptability, and cost-effectiveness the study results provide a comprehensive understanding of clinical and patient benefits the meta-analysis presented in **chapter 6** is another form of summative evaluation as it aims to demonstrate a pooled effect of comparable interventions on multiple clinical outcomes.

Unique challenges in the summative evaluation of eHealth with RCTs and meta-analysis

As mentioned before, one of the critical challenges of large-scale eHealth uptake and implementation is the uncertainty surrounding the effectiveness of eHealth interventions, particularly in terms of health benefit (40). Therefore, evaluating the effectiveness of eHealth interventions (summative evaluation) is essential to provide evidence of their impact on patients and healthcare systems. However, determining what outcomes should be included and considered important can be challenging, as stakeholders (patients, healthcare professionals, payers) may have differing perspectives. Having a clear value proposition helps prioritize outcomes and endpoints. Additionally, involving end-users in the design of the evaluation study facilitates the inclusion of outcomes that are meaningful to them, such as disease-related quality of life (**chapter 5**).

Randomized controlled trials (RCTs) have long been considered the golden standard for evaluating interventions (41). Based on the principles of randomization and creating controlled settings, RCTs are able to isolate the impact of an intervention and ensure comparable groups from the start, thereby minimizing the potential for systematic bias affecting the results. Similarly, meta-analysis as conducted **in chapter 6**, is considered the golden standard for synthesizing, and summarizing the results of multiple studies and forms the cornerstone of evidence-based medicine. By pooling, meta-analysis enhances statistical power and provides more accurate estimates of the interventions' effect (42). However, eHealth presents unique challenges that make RCTs less suitable for evaluating their effectiveness and poses difficulties in performing and interpreting meta-analysis results.

One challenge is that eHealth interventions are often complex interventions that are difficult to standardize and replicate across various healthcare settings. RCTs, typically conducted in tightly controlled settings with a highly selected study population and with additional resources, may fail to consider the complex healthcare context in

which the eHealth intervention is implemented. Consequently, RCT results may have limited applicability to patient outcomes once the trial has ended (43, 44).

Another challenge is the multiple component nature of eHealth interventions, which rely on an interplay between technology, human characteristics (e.g., patient behaviour, engagement with technology) and socioeconomic factors (e.g., reimbursement schemes). This complexity makes it difficult to attribute observed effects within an RCT to a specific component of the intervention. This is important to determine what works for whom to derive the effective components. In the case of the smart asthma inhaler programme **(chapter 5**) we indeed cannot solely deduce from results of our primary endpoint (medication adherence over 12 months follow up) which components of the programme (e.g., reminders and symptom tracker, patient portal) contributed to the potential beneficial effect.

The multi-component nature of eHealth interventions also presents comparability issues in meta-analysis. Meta-analyses are based on the premises that interventions are comparable (e.g., drug 'A' versus drug 'B'). Hence, problems arise when interventions are not comparable as is often the case with complex health interventions such as eHealth and the integrated disease management programs studied in **chapter 6** (40)**.** While we attempted to address this issue in **chapter 6** by performing subgroup analyses based on the dominant intervention component, the substantial heterogeneity observed in some subgroup comparisons indicates that comparison issues may persist, and no definitive conclusions can be drawn regarding the most effective components of an integrated disease management program. Moreover, interpreting the overall estimate of effect can be challenged by the interaction of the components with each other.

Alternative designs and recommendations

Alternative study designs, such as stepped-wedge trials or hybrid designs incorporating process outcomes, may be better suited to evaluate the effectiveness of eHealth interventions. These designs provide flexibility and adaptability, accommodating the complexities inherent to eHealth interventions (45). Factorial design and realist reviews should be considered as means to identify working components of eHealth technologies (46, 47) and more advanced meta-analytical techniques like meta regression (48), Network Meta Analysis (47) or Individual patient data meta-analysis can be deployed as alternative to traditional meta-analysis to identify working mechanisms of complex health interventions using pooled data.

Pragmatic trials (**Chapter 5**), performed in a real-world clinical practice setting, overcome some limitations of traditional RCTs. They resemble routine care as closely as possible and incorporate the natural variation observed among patients, including heterogeneity in study samples and co-morbidities. Consequently, the results are more applicable to the target population of the intervention (44). As with all study designs, the research process is a balancing act between maintaining internal validity while maximizing external validity (44, 49). To facilitate the design of a pragmatic trial and ensure alignment with the intended goals and purposes, researchers can

employ the PRECIS-2 tool, which allows for purposeful decision-making regarding trial design (50). Given that pragmatic trials, like most trials, can be financially demanding, researchers should consider performing a pilot study. This pilot study serves to refine study procedures, optimize recruitments strategies, minimize drop-out rates and inform decisions related to the allocation of time and budgetary resources (51).

Historically, meta-analysis has paid little attention to the role of context in the observed effect, typically including RCTs in tightly controlled settings. However, pragmatic RCTs often vary strongly in context (e.g., national healthcare system), and these contextual differences may impact the observed effects. Our subgroup analysis based on study country (as described in **chapter 6**) indicated that the context in which the intervention is implemented may be crucial for overall inference. Given the growing use of pragmatic trails to address the aforementioned challenges in eHealth evaluation, we propose that leading institutions like the Cochrane Library include an explanatory-pragmatic assessment in their quality assessment. This assessment would not only evaluate the quality of evidence using tools like GRADE-2, but also consider the external validity and generalizability of study results. This information can aid policymakers and healthcare leaders in assessing the applicability of the meta-analysis results to their specific context, considering factors such as study population, available resources, local needs, and adapting the intervention accordingly in a context-sensitive manner.

Finally, collecting qualitative data is crucial for evaluating eHealth interventions as it provides valuable insights into the human experience of using these interventions in real-world settings. Qualitative data complements the quantitative data by providing contextual information and a deeper understanding of the reasons behind observed outcomes. While clinical outcomes such as asthma control and medication adherence (**chapter 5**) offer an objective measure of the impact of the eHealth intervention, they do not shed light on the underlying reasons for those outcomes. In addition, qualitative data can provide insight in potential acceptance or implementation issues (52, 53).

To conclude, eHealth evaluation should be considered a continuous process which should include formative and summative evaluation moments throughout the development and implementation phase (10). In doing so, we recommend that researchers consider alternative designs as better options for evaluating eHealth interventions and include process outcomes and qualitative data for a comprehensive understanding of the impact of the eHealth interventions on health benefits.

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- Evaluation of eHealth should be considered a continuous process and include formative (i.e., to gain understanding for improvements) and summative (i.e., to measure performance or specific endpoints) evaluation moments.
- Researchers should be mindful of specific challenges related to eHealth (i.e., multicomponent, difficult to standardize and replicate across settings) that make RCTs less suitable for evaluating the effectiveness of eHealth and consider alternative designs.
- Pooling of effects of complex health interventions to give an overall estimate of effect is challenged by heterogeneity of the interventions and complicated by interaction between intervention components and contextual factors.
- Collecting qualitative data alongside quantitative data is essential for evaluating eHealth interventions. Qualitative data provides valuable insights into the human experience, contextual information, and deeper understanding of observed outcomes.

THEME 5 EFFECTIVE SCIENCE COMMUNICATION AND SOCIETAL IMPACT

Transferring knowledge on for example evidence on effectiveness of eHealth is essential to benefit patients and impact society as a whole. However, a substantial gap exists between knowledge and practice **(Challenge five, General introduction**). Science communication plays a vital role in bridging this gap by communicating complex scientific knowledge in an accessible way, thereby promoting understanding, facilitating engagement between public and scientists, and fostering informed decision-making based on evidence (54). These are prerequisites in creating societal impact (55). Science communication also plays a significant role in building trust in science, fostering open dialogue and countering misinformation (56).

The process of translating knowledge, as discussed in **chapter 8,** is pivotal for effective science communication to the public. Knowledge translation and dissemination is complex and entails many distinct aspects (i.e., knowledge synthesis, creation, dissemination, exchange, and application). In **chapter 8** we focused on the knowledge creation process and provided a systematic approach to facilitate effective knowledge creation in healthcare. By offering a step-by-step approach we help academics in navigating the complex process of translating research evidence in practice or policy. This approach facilitates evidence-informed decision-making, enhances the uptake of research findings, and ultimately leads to societal impact. It is particularly relevant that academics have the right tools at their disposal, as they are increasingly expected to disseminate their research findings outside the scientific community and engage in societal impact. However, translating research knowledge into societal impact requires skills, experience, and practices that are often absent from doctoral programs and academic discourse (57, 58).

Recognizing the importance of societal impact, significant changes have taken place over the past decade in the academic reward and evaluation system, at both system and disciplinary level. Examples include the installation of U.K.'s Research Excellence Framework (i.e. reward system that rewards universities that demonstrate impact) and the inclusion of societal impact in research proposal evaluation schemes by funding bodies (59). In the Netherlands, academic discourse has embraced societal impact through the New Recognition and Reward system (60). As a result, efforts in science communication, public engagement and societal impact align more closely with academic reward structures (57). This recognition opens up opportunities for individuals to pursue different career paths based on their aspirations, qualities and opportunities, thereby 'redefining the balance between rewards for research, education, societal impact and leadership' (60). However, there is room for improvement in the weight given to societal impact and non-scientific outreach efforts in the assessment of PhD students if we are to really perpetuate the current system, thereby offering full room for differentiation in academic (early) career paths. By doing so, we - at the same time - recognize that non-scientific communication and directly engaging in societal impact may not be for everyone and requires specific skills, experience, and interest.

Finally, to promote societal impact and effective science communication, universities should institutionalize support for impact design and non-scientific communication, similar to how they provide support for data management or statistical analysis (52). By doing so, institutions can stimulate and facilitate societal impact, ensuring that effective science communication becomes an integral part of academic endeavours.

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- Effective science communication is crucial for promoting public and patient involvement in science. It bridges the gap between scientists and the general public, promotes understanding, and facilitates informed decision-making based on evidence.
- Translating scientific knowledge into societal impact requires effective knowledge creation and dissemination. Providing a systematic approach to knowledge creation in healthcare enhances evidence-informed decision-making and may benefit its societal impact. Doctoral programs and academic discourse should include training in these skills.
- Newly implemented Reward and Recognition systems provide room to participate in science communication and public engagement with performances being more closely aligned with academic reward structures. However, more weight should be given to non-scientific outreach efforts in the assessment of PhD students.

CONCLUDING REMARKS

This dissertation demonstrated how end-users and stakeholders can be actively involved in the development and evaluation of eHealth. It emphasized the importance of facilitating the expression of people's needs and including the voices of those who stand to benefit the most from eHealth but are often overlooked. Through participatory design, we successfully demonstrated how to design eHealth solutions to meet people's needs, foster mutual understanding, and promote reciprocity. Additionally, we explored the potential of persuasive game in facilitating behaviour change and highlighted the importance of stakeholder involvement for sustainable implementation. Finally, we provided future researchers with a tool to identify eHealth literacy needs and ways to include individuals with limited health literacy in eHealth design, which are essential components for achieving equitable eHealth.

In conclusion, we must keep in mind the proverbial wisdom that "A journey of thousand miles begins with a single step." The digitalisation of healthcare is an ongoing process which requires us to take different viewpoints in how we develop and evaluate digital health interventions and consider ethical perspectives. It necessitates a critical examination of the research paradigms guiding the development and evaluation of eHealth. Reflecting on our work, this dissertation does not provide a simple solution for how to develop and evaluate eHealth interventions, but rather builds upon the knowledge and scholarships of those who have preceded us in this rapidly evolving field. Above all, we invite and encourage discussions and open dialogues among researchers, designers, ethics, and most importantly those directly impacted by these eHealth technologies.

It is Saturday afternoon, June 20, 2020. Mrs. V sits in her garden. Next to her lies her new smartphone. With a satisfied smile, she gazes at the screen. After four instruction sessions with her buddy from 'Blijf in Beeld', she has managed to video call her friend in the eastern part of the country. It took effort and did not come naturally, but through practice, perseverance, and simply giving it a try, she succeeded.

She glances at the time on her smartphone. It's a quarter past five. The doctor's office is closed, but she realizes that she might be able to schedule an appointment through the online patient portal.
As a little bird flies by, she contemplates on how good it feels to be connected once more and decides that it is a fantastic feeling to have the sense of fully participating in society again.

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