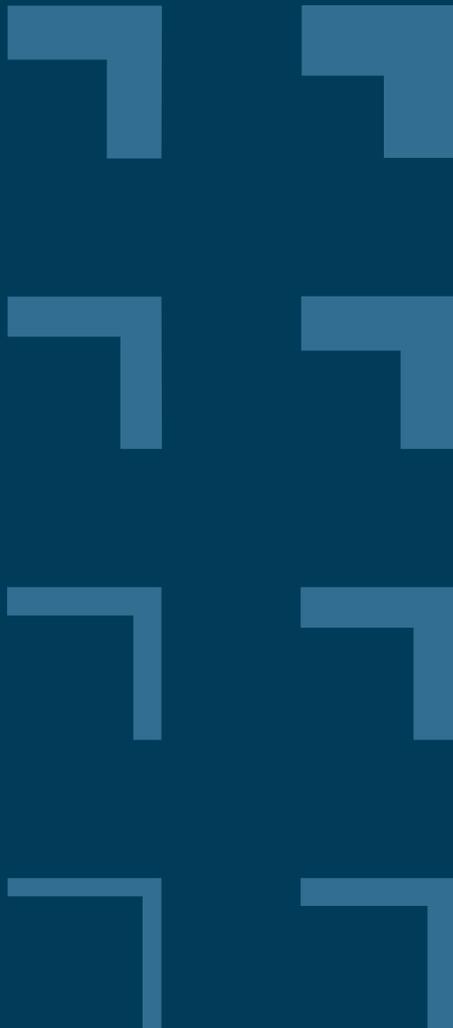**Technology and Innovation Management**
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Belief Elicitation Study: Identifying salient beliefs of patients towards the use of mHealth

Christine Hennings*, Cornelius Herstatt

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Hamburg University of Technology (TUHH)

Institute for Technology and Innovation Management

Am Schwarzenberg-Campus 4
D-21073 Hamburg

Tel.: +49 40 42878 3833
Fax: +49 40 42878 2867

christine.hennings@tuhh.de
www.tuhh.de/tim
*corresponding author

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Abstract

Mobile health (mHealth) with its unique attributes (e.g. instant connectivity, convenience, personalization) is largely considered as a new healthcare paradigm transforming health services around the world. mHealth has also gained popularity in research, especially in the field of technology adoption. According to the Theory of Planned Behavior (TPB), a widely used and well established theory to explain behavior, salient beliefs are considered to be the dominant determinants of a person's intentions and actions. In the context of technology adoption identifiying salient beliefs is essential when thinking of effective intervention strategies and marketing strategies by e.g. public health policers and app producers. This study is from qualitative nature and contains a German sample, aiming to answer the following research question: *What are the salient beliefs patients with chronic conditions have towards the use of medical apps (mHealth)?*

The results show behavioral, normative and control beliefs of patients. Study participants in particular value the high comfort, a good, mainly administrative, support in daily disease handling and a feeling of increased control over the disease caused by using medical apps. The most frequent negative beliefs were insecurity about data privacy issues, a feeling of becoming dependent on the app and the fear of data loss in case of a lost or broken smartphone. In regard to normative beliefs patients see the physician as an important individual to approve or disapprove their use of medical apps. Notably in this case is, that physicians were the most frequent mentioned group for positive normative beliefs as well as for negative normative beliefs. In regard to control beliefs respondents perceived that among the most frequent facilitators that would allow the use of mHealth apps were individual requests for a specific app feature, a high usability/ease of use of the app and device compatibility of the app with other medical devices. Salient beliefs about barriers that would allow the use of mHealth apps were a low quality of an app, the absence of a suitable smartphone and a high complexity of the app. The results are potentially beneficial for app producers to gain insights for their marketing initiatives but also for public health policy.

1   Intro

Mobile health (mHealth) apps have increasingly gained popularity in the last couple of years: In the iTunes app store and the Google Play store, the two major app stores, are 98,248 and 97,040 respectively, active apps available for download in the category Health and Fitness (Pocketgamer.Biz, 2018; AppBrain, 2018). In general, mHealth apps aim to improve patients' health through multiple different functionalities as e.g. provision of medical information, monitoring and documentation of vital parameters and the exchange of data with others.

mHealth has also gained relevance from a public health policy point of view. Not only the World Health Organization (WHO) identified advantages of mHealth as, for example, cost effectiveness, real-time access to information and availability (World Health Organization, 2011), but also the European Commission emphasizes the potential of mobile apps for patients, especially for those with chronic diseases, in their report on the eHealth Action Plan 2012-2020 (Ayuso, 2014). In General, mHealth apps can be advantageous for patients in many important health-related domains as e.g. chronic disease management, mental health and patient education (Kao & Liebovitz, 2017). It is assumed that technologies like telehealth,

where mHealth can be a part of it, has the potential to shift the care paradigm from crisis intervention to promoting wellness, prevention and self-management (Kaplan & Litewka, 2008). Moreover, today people have a very strong attachment to their mobile phone and tend to carry them everywhere leading to new opportunities for continuous symptom monitoring and connecting patients with providers outside of health care facilities (Hamine, Gerth-Guyette, Faulx, Green, & Ginsburg, 2015).

Having these potential tremendous effects on public health it is important for public health policers but also for app producers to identify factors influencing the adoption of mHealth. A widely used and well established theory to explain behavior in regards to technology adoption is the Theory of Planned Behavior (TPB) by Ajzen (1991, 1988). The TPB has been successfully applied in many contexts to predict numerous different behaviors, including health behaviors (e.g. addictive behavior, eating behavior). In different studies Ajzen, Joyce, Sheikh, & Cote (2011) showed that having accurate information is neither necessary nor sufficient for decision-making. Instead, what determines intentions and actions is subjectively held information (i.e., beliefs) people have about the behavior of interest (Ajzen et al., 2011). Those underlying beliefs refer to a person's beliefs about the likely positive or negative consequences of performing a behavior (behavioral beliefs), to the normative expectations of important referent individuals or groups (normative beliefs) and to the perceptions about the presence of factors that facilitate or impede the adoption of a given behavior (control beliefs) (Ajzen, 1991). Referring to the TPB it is essential to elicit the salient beliefs towards a behavior from the target population as the salient beliefs are considered to be the dominant determinants of a person's intentions and actions (Ajzen, 1991).

In the relatively new field of mHealth research, several quantitative studies have been conducted to identify factors influencing the adoption of mHealth among patients and health providers (e.g. Hoque & Sorwar, 2017; Lee & Han, 2015; Okazaki, Castañeda, Sanz, & Henseler, 2012; Sezgin, Özkan-Yildirim, & Yildirim, 2018; Sun, Wang, Guo, & Peng, 2013). To my knowledge, neither of those studies researching the patient perspective has identified the salient beliefs patients with chronic conditions hold about mHealth apps. Yet identifying the salient beliefs is the preferred method for contextualizing theories of behavior to a specific setting, with a new population and a new behavior of interest (Holden & Karsh, 2010) and also provides more insights on the underpinning adoption decision.

The aim of this study is to identify salient beliefs (behavioral, normative, and control beliefs) in relation to mHealth among patients with chronic diseases. This is important to fill the research gap in regards to mHealth adoption and gain insight into the underlying cognitive foundation of the behavior of interest (Ajzen, 2002). This is essential when thinking of effective intervention strategies and marketing strategies by e.g. public health policers and app producers.

2　mHealth

Research on mHealth

With an increasing penetration of mobile devices, mHealth is seen as a promising mean to support an efficient and effective provision of healthcare (Agnihothri, Cui, Delasay, & Rajan, 2018). The World Health Organization states that no standardized definition of mHealth has been established (World Health Organization, 2011). It goes on to use the definition of mHealth as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal

digital assistants (PDAs), and other wireless devices".

Research studies regarding behavior mainly consider mHealth as a technology, studying people's adoption intention using the *Technology Acceptance Model* (TAM), the *Unified Theory of Acceptance and Use of Technology* (UTAUT) model , the TPB model or other theoretical constructs. mHealth adoption research focuses on either the adoption by health providers (e.g. physicians, nurses) or by patients while the former is prevailing so far (Hoque & Sorwar, 2017; Sun et al., 2013).

Very recently Zhao, Ni, & Zhou (2018) conducted a meta-analysis to develop a comprehensive framework regarding the adoption of individual mobile health services. They included 35 studies containing mHealth adoption by patients as well as by professionals. Particularly noticeable is that most of the included studies are from Asia, the US, or Canada, only very few from Europe. For example, Hung & Jen (2012) examined the determinants of adopting mobile health among young and middle-aged adults in Taiwan and showed that determinants vary between groups, employing TAM. Hoque & Sorwar (2017) investigated the underlying factors influencing the adoption of mHealth by urban elderly in Bangladesh taking the UTAUT as the theoretical basis.

Influence factors not included in the popular technology adoption models have also been researched. For example, Guo, Zhang, & Sun (2016) proved the existence of the privacy–personalization paradox in the mHealth context of consumers. On the one hand privacy concerns were found to be negatively related to adoption intention, on the other hand perceived personalization was positively related to adoption intention. Guo et al. (2015) based their study on the Protection Motivation Theory and found factors in regard to perceived risk to influence the adoption intention of mHealth.

Dwivedi et al. (2016) did a cross-country study with participants from the US, Canada and Bangladesh showing that cultural differences have a decisive impact on modelling adoption behavior. Considering this it is necessary for health policy makers to know the country specific factors influencing mHealth adoption. Different from previous research, this study is from qualitative nature and contains a German sample, aiming to answer the following research question: *What are the salient beliefs patients with chronic conditions have towards the use of medical apps (mHealth)?*

Determining the salient beliefs of patients in regards to using mHealth apps seems to be very important as there are some special characteristics in this context that differ from other technology adoption contexts and might also be specific to the German healthcare system.

1. High relevance for patients and involvement of personal health data

In this particular context of patients dealing with chronic diseases it is assumed that patients are highly involved when considering mHealth apps for their disease management. According to Zaichkowsky (1985) involvement is "A person's perceived relevance of the object based on inherent needs, values and interests". Patients with chronic conditions inevitably have to engage with their disease on a daily basis. For example, they have to take medication, they have to attend appointments as physiotherapy, they have to measure vital parameters or inject insulin. Consequently, patients have a high need and interest with everything affecting their handling with the disease. When now evaluating to integrate something new (as mHealth apps) in the disease handling routine, it is very likely that patients have a critical look on the issue.

Besides the important point that medical apps could affect parts of the disease handling, patients are probably also thinking thoroughly

about mHealth apps because most of those apps require data input, in many cases personal health data as e.g. vital parameters. As Culnan & Armstrong (1999) have noted, "in an absolute sense, individuals surrender a measure of privacy whenever they disclose personal information". As users of mHealth apps are often required to disclose personal information (e.g. registration is compulsory for app usage), it is presumed that many users have privacy concerns about who has access to information that is disclosed when using an mHealth app and how the information disclosed are used. In General, individuals will disclose personal information if they perceive that the overall benefits of disclosure are at least offset by, if not greater than, the assessed risk of disclosure (e.g. M.J. Culnan & Bies, 2003; Dinev & Hart, 2006). Following this argumentation, mHealth users most probably evaluate the benefits of using a medical app higher than the risk of data disclosure.

Due to these two contextual factors, namely a high relevance of mHealth apps for disease handling and personal (health) data involved, it is assumed that patients have a differentiated opinion about medical apps.

2. Multiple potential sources of influence on patients' mHealth adoption

According to Agnihothri et al. (2018) mHealth has the potential to transform healthcare delivery with the help of multiple stakeholders (patients, providers, insurers, technology developers, and policy makers). The existence and involvement of multiple stakeholders and their partly complex interlinking is one of the specific contextual factors of healthcare.

In Germany patients normally have their general practitioner, who is their first point of contact when needing medical treatments (excluding emergency cases). Patients with chronic conditions have regular appointments with their general practitioner or specialist (e.g. diabetologist) to monitor the process of the

chronic condition. As these patient – physician relationships normally exist on a long-time basis, it is assumed that the physician might have influence on the patient's adoption decision of mHealth apps. Studies showed that physicians do have a significant influence on patients' health-promoting behavior changes, for example in regard to smoking cessation and weight loss (e.g. Kaplan, Greenfield, & Ware, 1989; Lindsay F, Bergson, & Lancaster, 2008; Rose, Poynter, Anderson, Noar, & Conigliaro, 2013) and that health care providers play a vital role in guiding patients' practices of chronic disease management (Dou et al., 2017). Sun et al. (2013) showed in their mobile health technology adoption study that the opinion of others is particularly important to the elderly people.

In the case of mHealth adoption it is assumed to see a similar effect, namely that physicians could foster or inhibit the use of mHealth adoption when expressing their general attitude towards the use of mHealth apps or giving concrete recommendations to the patient.

Another important stakeholder in this context is the health insurance. Many patients with chronic conditions are regularly applying for certain medical devices (e.g. insulin pump). For the application a proof that the patient handles the disease responsibly must be shown by e.g. handing in a diabetes diary of the last three months. Having these requirements, patients start to look for comfortable ways to fulfill them, e.g. by evaluating mHealth apps. Not only in this specific case health insurances might have influence on the patient's adoption decision, but health insurances in Germany have recently also started to release and promote own health apps for their customers (e.g. TK-DiabetesTagebuch by Techniker health insurance).

Next to the key stakeholders within the healthcare system, there is another group of people that might have a great influence on the

adoption decision for patients: Persons from the private environment as family members, spouses, friends or colleagues. These people care much about the chronically-ill relative or friend, they support them, inform themselves about the disease and news around it, and look for new ways that could help to deal with the disease. For example, children are helping their parents or grandparents to familiarize with mHealth technology, they explain the use of health apps or e.g. set up medication reminders.

Another potential source of influence on adopting mHealth apps are online support groups. Due to the increasing familiarity with online social networks like Facebook and ubiquitous access to the Internet, online support groups have becoming very popular among patients in the years. People suffering from the same disease gather virtually to gain information, share experiences, provide emotional support to each other, actions that help people to cope with the disease (e.g. Attard & Coulson, 2012; Leimeister, Schweizer, Leimeister, & Krcmar, 2008; Shaw, McTavish, Hawkins, Gustafson, & Pingree, 2000).

Taking into account the different potential influence groups it is important to find out the normative beliefs patients have in regards to mHealth apps, in particular what individuals or groups they think would approve or disapprove the use of medical apps.

3   Method

Data Collection and Participants

The purposeful sampling technique, a widely used sampling method in qualitative research for the identification and selection of information-rich cases related to the phenomenon of interest (Patton, 2002), was applied in this study. The phenomenon of interest are patients with chronic conditions, who are the ideal target group for mHealth apps. The precondition for participants was to

3. Technology compatibility

For many mHealth apps it is possible or even necessary to connect them with other software or medical devices (e.g. blood glucose meter), requiring compatibility. Compatibility refers to the capacity for two systems to work together. A study by Hamine et al. (2015) showed that patients with chronic diseases are using wireless or Bluetooth-compatible medical devices to transmit information wirelessly to mobile phones and computers as part of their disease management. In this context the mHealth app choice might be influenced by the medical device a patient is using or by other software systems where the patient wants/has to connect to. For example, some producers of blood glucose meters are releasing own apps that can be connected to the device and e.g. enables an easy data transfer to the app via Bluetooth. Patients might be bound to the medical device producer's apps and therefore, not completely free of choice.

Another example of required compatibility of systems refers to diabetologists offering their patients to transfer the diabetes diaries to the physician's computer system making it necessary that the diabetes app is compatible with the physician's system.

These are possible facilitating conditions that might influence the adoption of mHealth.

have at least one chronical disease (e.g. diabetes, depression, Parkinson's disease). According to the TPB questionnaire guidelines of Francis et al. (2004), a belief elicitation study can be conducted with focus groups, individual interviews, or a mailed questionnaire. For this study an online questionnaire was chosen.

Participants were recruited in online facebook groups that each have a certain chronic disease as a group topic. The study description and link to the online questionnaire in German language was posted in the online groups. In the survey description was stated that sharing the survey

with other chronically-ill patients is welcome. It is assumed that the members of the online groups are mostly people suffering from this disease themselves or maybe relatives of a person with the chronic condition. To ensure best possible that only people with chronic conditions take part in the survey, the first question asked whether the participant has a chronic disease or not. In case this minimum criterion was not met, participants were thanked for their willingness to participate but excluded from the survey. As an incentive a lottery of three Amazon vouchers a €20 was announced in the survey description. The elicitation study was conducted in June 2018 (over a period of 8 days), using the survey software QuestionPro.

The sample consisted of 54 patients (35 females; 17 males; 2 unknown), whereof 37% of participants are in the age range from 26 to 35 years. For demographic details see Table 1.

The majority of study participants (75.9%) is currently using medical apps or has used medical apps within the last 12 months. 22.2% of respondents have no app experiences or they date back more than 12 months and the rest did not answer that question. Moreover, all respondents have a smartphone as all answered to use apps in general at least a few times a month. More precisely, 83.3% of respondents use apps a few times a day, 9.3% several times per week and 7.4% still a few times a month.

Age		Gender		Disease	
18-25	9 (16.7%)	Female	35 (64.8%)	Diabetes	26 (48.1%)
26-35	20 (37%)	Male	17 (31.5%)	Multiple Diseases (multimorbid)	11 (20.4%)
36-45	7 (13%)	No answer	2 (3.7%)		
46-55	9 (16.7%)			Asthma	5 (9.3%)
> 55	6 (11.1%)			Parkinson's disease	4 (7.4%)
No answer	3 (5.6%)			COPD	1 (1.9%)
				Depression	1 (1.9%)
				Chron. Back Pain	1 (1.9%)
				Colitis Ulcerosa (chron. bowel disease)	1 (1.9%)
				No answer	4 (7.4%)

Table 1: Sample Demographics (N=54)

Measures

To identify the salient beliefs of patients this study is based on the TPB and follows the recommended procedure for a belief elicitation study by Ajzen (1991).

The TPB is an extension of the theory of reasoned action (TRA) by Fishbein & Ajzen (1975) and has the main goal to predict and understand human behavior. The TPB postulates that three factors, namely, attitudes, subjective norms, and perceived behavioral control jointly determine behavioral intentions, which in turn predict the actual behavior (see figure 1 for a structural diagram of the theory).
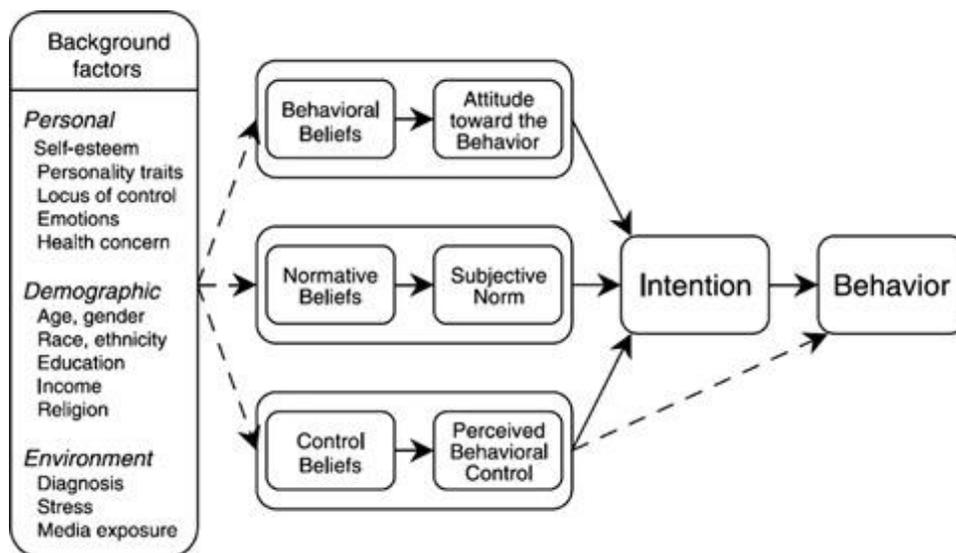
Figure 1: Ajzen's (1991) Theory of Planned Behavior

Attitude is determined by the individual's beliefs about outcomes or attributes of performing a particular behavior (behavioral beliefs), weighted by positive or negative evaluations of those outcomes or attributes (Fishbein & Ajzen, 1975). The TPB predicts that the more positively an individual evaluates a particular behavior, the more likely the individual will intend to perform that behavior. In regard to this context, when patients believe that using medical apps mainly produces positive outcomes, their attitude towards this behavior will be favorable. Contrarily, if they associate medical apps with mainly negative consequences, their attitude will be unfavorable.

Similarly, a person's subjective norm is determined by his or her normative beliefs, that is, whether relevant others approve or disapprove performing a particular behavior, weighted by his or her motivation to comply with those referents (Fishbein & Ajzen, 1975).

Aside from a favorable attitude and subjective norm, individuals need a degree of certainty that they are able to perform a behavior successfully. Perceived behavioral control refers to the perceived ease or difficulty of

performing the behavior and it is assumed to reflect past experience as well as anticipated impediments and obstacles (Ajzen, 1991). Perceived control is determined by control beliefs concerning personal and external factors that either facilitate or impede action, weighted by their perceived power or the impact of each control factor to facilitate or inhibit the behavior.

In General, the more favorable the attitude and subjective norm with respect to a behavior, and the greater the perceived behavioral control, the stronger should be an individual's intention to perform a particular behavior (Ajzen, 1991).

The TPB deals with the antecedents of attitudes, subjective norms, and perceived behavioral control, antecedents that are considered as factors to determine intentions and actions. These antecedents, the so called salient beliefs, are considered to be the dominant determinants of a person's intentions and actions (Ajzen, 1991).

When defining the behavior of interest the Target, Action, Context, and Time (TACT) elements should be considered (e.g. Francis et al., 2004). In this study the behavior of interest

is the usage of mHealth apps for the patient's disease handling. Target refers to mHealth apps, the action is to use it, the context is the disease handling. The time element was not specified as it is implicitly clear that it could be started directly as the patient/participant has already a chronic condition. The behavior of interest was the same for all beliefs questions (behavioral beliefs, normative beliefs and control beliefs). In a belief eliciation study it is important to ask open questions where participants can freely list their thoughts instead of providing a preconceived list of belief statements. A predefined selection of belief statements will tend to contain associations that are not readily accessible in the population (Ajzen, 1991).

Participants were asked to write down the thoughts that came to mind in in association with behavior of interest, i.e. the use of medical apps. Specifically, they were asked to list (a) the advantages and disadvantages of performing the behavior, (b) the individuals or groups who would approve or disapprove of their performing the behavior, and (c) the factors that could facilitate or making it difficult perform the behavior. See the whole questionnaire in the appendix.

Content Analysis

A content analysis was performed to extract the salient beliefs among patients, i.e. the beliefs that are common in this target population. At the beginning all answers have been translated from German to English. Responses to each question were then read through and separately content analyzed. Responses were coded and similar responses were grouped together to categories. Categories were then listed in order of frequency for behavioral beliefs, normative beliefs and control beliefs. Given the small amount of data coding was done by hand rather than using qualitative software. This approach of analysing is common in belief eliciation studies (Ajzen, Nichols, & Driver, 1995; Francis et al., 2004).

4   Results

Behavioral Beliefs

In terms of positive behavioral beliefs, the study elicited in total 110 salient beliefs from the respondents. The following table shows the frequencies of the positive behavioral beliefs, given to the question, "What do you believe are the advantages for you when using medical apps?" Respondents perceived that among the most three frequent advantages about using mHealth apps were a very high comfort, a good, mainly administrative, support in daily disease handling and a feeling of increased control over the disease.

Theme	Frequency	Per-centage	Description	Example quotes
Higher comfort/ease of use	34	30.91%	Ease of use and comfort that apps offer (e.g. compared to analogue documentation)	-"Simplified documentation" -"I always have my smartphone with me anyway. Therefore, it is easier for me to enter data in app as to carry an analog diary with me." -"Evaluations are clearer through graphics than naked numbers on paper"
Support in daily disease management	23	20.91%	Support in medication management,	-"More regular intake of the medication"

			adminstration of appointments and contacts	-"get push messages so I take my medication on time" -"management of appointments and contacts"
Increased control over disease	16	14.55%	Higher control over disease (e.g. current health status always at hand)	-"Better control over diabetes by controlling and keeping a log/diary" -"monitor my state of health"
Get latest information on disease	8	7.27%	Information regarding disease as e.g. latest research, advice how to handle disease	-"links to current research results" -"tips on dealing with disease"
Get to know myself better in regards to disease	6	5.45%	Recognization of patterns	-"Get to know limits better" -"find triggers that reinforce disease"
Data are saved in cloud	4	3.64%	Data are saved securely in cloud	-"Advantages of automated data storage locally and on the Web" -"Data are saved in the cloud"
Easy data transfer to others	4	3.64%	Data can easily be shared with others (e.g. physician, family)	-"possibility to share data with family" -"fast interface for data transfer to the physician"
Data from different sources/devices are bundled	4	3.64%	Data from different sources are integrated in one place	-"It's easier to have everything integrated in one place" -"you can collect data from different devices"
Contact/exchange with others having suffering from same disease	3	2.73%	Contact to other persons/share experiences	-"Community" -"Exchange of experiences" -"contact with other chronic patients"
No paper involved/saves paper	3	2.73%	App usage replaces documentation on paper	-"digital documentation, no paperwork" -"saves paper"
App serves as control system	3	2.73%	App is used as alarm system (e.g. control during sleep)	-"The app controls at night how much air I need to get no breathing misfires." -"Alarm functions for exceeding the limit values"
App increases motivation to deal with disease	1	0.91%	Motivation to tackle disease is increased	-"motivation to manage the disease"
Discret/unobtrusive to use app in public	1	0.90%	Discrete use is possible	-"It is not conspicuous in public."
Non-responses	1	0.91%	Question not answered	N/A, blank, unrelated, illegible etc.
N=54 Total responses: 111 Total pos. beh. beliefs responses: 110 Average # responses/participant: 2.04				

Table 2: Overview of positive behavioral beliefs

In total less negative behavioral beliefs were mentioned. Ten respondents answered explicitly that they do not see any disadvantages of their use of medical apps. In total, the study elicited 49 salient negative behavioral beliefs. The most frequent negative beliefs were insecurity about data privacy issues, a feeling of becoming dependent on the app and the fear of data loss in case of a lost or broken smartphone. The following table shows the frequencies of the negative behavioral beliefs.

Theme	Frequency	Percentage	Description	Example quotes
Data privacy is suspect	18	36.73%	Unsecurity about use of data and data security issues	-"Some medical apps may be questionable about data privacy" -"Uncertainty that somebody else can somehow access the data"
Dependency on app	7	14.29%	Loosing natural body perception and relying too much on app	-"If you lose your balance between taking responsibility for your illness yourself and relying too much on apps, it will be difficult if they do not work" -"natural perception is reduced"
Data loss in case of damaged or lost smartphone	6	12.24%	Data loss when data are locally saved on smartphone	-"Data are not safe. If something happens with the smartphone, all data are lost" -"If there is a smartphone crash, the data is gone or also in case of theft"
Difficulties with device compatibility	2	4.08%	Compatibility between apps and other medical devices	-"For most apps, automatic data transfers are limited to a few products"
Dependency on smartphone battery	2	4.08%	Technical dependency	-"lack of battery capacity"
Disease becomes too prominent in life through app usage	2	4.08%	Disease becomes too prominent in life through app usage (e.g. smartphone always at hand)	-"by the constantly visible data statistics the own pressure, to make it better" -"That one reads too much about it"
Value is uncertain	1	2.04%	Value o fapp usage is not clear	-"Value is uncertain"
Risk for own health	1	2.04%	Risk for own health (e.g. mistake by app can be life-threatening)	-"When calculating units, errors can occur that can become life-threatening"
Inconvenient to carry all equipment	1	2.04%	Inconveniance aspects	-"The equipment must always be carried"
Risk that someone discovers disease	1	2.04%	Risk that someone discovers disease	-"Someone might know about my disease"
Risk of misuse by user	1	2.04%	Incorrect use of app by user	-"Risk of wrong application by user"

Too expensive to have premium version of app	1	2.04%	Only premium versions offer complete functionality	-"Disadvantages are sometimes that you need a pro version in some apps in order to unlock other features"
Smartphone usage is already too extensive	1	2.04%	App usage increases time spent on smartphone	-"I already spend a lot of time on the mobile anyway"
Calculation in app less precise than manual calculation	1	2.04%	Doubt in precise calculation of the app	-"(initially) less precise than an exact calculation"
Too much effort to protocol all values	1	2.04%	App usage is time consuming	-"It takes a lot of effort to log everything"
Not every smartphone fulfills technical requirements for app usage	1	2.04%	Technical requirements that app requests	-"Technical requirements (for example, not every mobile phone has NFC, which you need to read the FreeStyleLibre sensor)"
Other smartphone features and apps distract when using medical app	1	2.04%	Harder to concentrate on med. app usage due to general distractions on smartphone	-"Sometimes you forget it because maybe a message comes in between"
Physician does not accept digital version of diary	1	2.04%	Physician does not accept digital version of diary	-"My doctor is very old-fashioned and wants the values in paper form. He prefers self-written diaries. So I have to do everything twice."
Non-responses	15	23.44%	Question not answered	N/A, blank, unrelated, illegible etc.
N=54 Total responses: 64 Total neg. beh. beliefs responses: 49 Average # responses/participant: 0.90				

Table 3: Overview of negative behavioral beliefs

Normative Beliefs

In regard to the positive normative beliefs as expected different stakeholders from the healthcare system and other individuals or groups were mentioned. By far the most mentioned group that respondents think of who would approve the regular use of medical apps are physicians.

Theme	*Frequency*	*Per-centage*	*Description*	*Example quotes*
Physician	17	50.00%	Physician (in ambulatory care)	-"In many apps you find a graphical representation of the values within the data exports (e.g. diabetes diaries). The diabetologists really like that because they see the history."

				-"My physician thinks it's very convenient, that I can send him my medication plan via mail."
Personal environment	10	29.41%	Personal environment (family members, spouses, friends and colleagues)	-"my mum because she says to me that I should have my mobile phone always with me. Due to this factor it should be easier with an app than with an analogue diary"
Health insurance	3	8.82%	Health insurance	-"Maybe health insurances to have an eye on my values (health status)"
Pharmacy	1	2.94%	Pharmacy	-"maybe my pharmacy"
App producers	1	2.94%	App producers	-"The companies, that analyse my (usage) data, because they can earn money with it and they can draw conclusions regarding my health status"
Researchers	1	2.94%	Researchers	-"Research, because they get information"
Pharmaceutical companies	1	2.94%	Pharmaceutical companies	-"Pharmaceutical companies, they want to increase product loyalty"
Non-responses	31	47.69%	Question not answered	N/A, blank, unrelated, illegible etc.
N=54 Total responses: 65 Total pos. normative beliefs responses: 34 Average # responses/participant: 0.63				

Table 4: Overview of positive normative beliefs

Coming to the individuals or groups that would disapprove the regular use of medical apps, the group of physicians (n= 5) was also the most frequently mentioned group but with a significant lower mentioning compared to the question for approving social norms. Noteworthy is that many participants (n=22) answered that they do not see any individuals or groups who would disapprove their regular use of medical apps.

Theme	Frequency	Per-centage	Description	Example quotes
Physician	5	38.46%	Physician (in ambulatory care)	-"As mentioned in the previous question, there are also physicians who do not like digital and printed things because they think the patients do not deal enough with their illness" -"Physicians, because data are transmitted differently for each software / app"
Other chronically-ill people	4	30.77%	Other chronically-ill people (e.g. suffering	-"Generation Grandma and Grandpa, 'In former times dad went without….'"

			from the same disease)	-"Most of the chronically-ill people themselves"
Personal environment	2	15.38%	Personal environment (family members, spouses, friends and colleagues)	-"My grandparents" -"Friends, they think that with storing the data on their cell phones one would disclose too much information"
Political committees	1	7.69%	Political committees	-"Certain committees. I can not remember the name. I call you "the eternally yesterday, who themselves have no chronic disease but want to determine".
Data protectionists	1	7.69%	Data protectionists	-"Data protectionists, probably, because they regard medical apps as risks"
Non-responses	41	75.93%	Question not answered	N/A, blank, unrelated, illegible etc.
N=54 Total responses: 54 Total pos. normative beliefs responses: 13 Average # responses/participant: 0.24				

Table 5: Overview of negative normative beliefs

Control beliefs

With respect to positive control beliefs, i.e. the factors that could facilitate performing the behavior, many different were named, although twelve beliefs were only mentioned three times or less. The study revealed 59 salient beliefs from the respondents. The most frequent facilitators that would allow the use of mHealth apps were individual requests for a specific app feature, a high usability/ease of use of the app and device compatibility of the app with other medical devices. The following table shows the frequencies of the positive control beliefs.

Theme	*Frequency*	*Per-centage*	*Description*	*Example quotes*
Feature request	15	25.42%	Wish for a specific feature	-"possibility to enter medication dose" -"Accoustic reminder" -"If there would be a backup for the data"
High usability/ease of use	11	18.64%	App should be easy to use	-"It's easy since you have your smartphone always with you" -"simple use" -"easy to use"
Device compatibility/easy connection to devices	7	11.86%	Compatibility with medical devices (e.g. blood glucose meter)	-"Easy pairing with device, if necessary via Bluetooth or Wifi" -"Automatic data transfer for all blood glucose meter via bluetooth"
Easier communication with physician	4	6.78%	Easier communication with physician (e.g.	-"Easy communication with physician (via mail or usb stick)" -"Send data to physician via app"

			reduce number of appointments)	-"If it would reduce the number of physician visits"
Clear value for specific disease	3	5.08%	Clear value for disease (e.g. disease specific feature)	-"app adapted to concrete disease" -"If apps would have extremly good and useful tools
Apps are available free of charge	3	5.08%	No or very low costs of app	-"free of costs or very cheap" -"If they would be free of charge
Clear guidance for app usage	3	5.08%	Clear guidance for app usage (e.g. for elderly people)	-"Introduction and recommendations because there are so many apps out there" -"Better understanding for layman and elderly people"
High quality of app	3	5.08%	High quality of app (e.g. reliability, stable operation, appealing design)	-"if app would run stable" -"appealing design"
Better access to the Internet	2	3.39%	Better access to the Internet/higher network coverage	-"Free access to the Internet" -"mobile internet is not available or very slow in the countryside"
App can integrate different data sources	2	3.39%	App can integrate different data sources	-"If app could bundle data from different sources" -"summary of typical diseases in one app"
Change of societal climate towards chronically-ill people	1	1.69%	Change of societal climate towards chronically-ill people	-"Change of societal climate towards chronically-ill people"
Data privacy is ensured	1	1.69%	Data privacy is ensured	-"Data privacy"
Fun to use app	1	1.69%	Fun to use app (gamification)	-"With one of my apps one get reminded playfully to enter values and one can collect points to win challenges"
Rewards for using med. app	1	1.69%	Rewards for using med. app	-"If I get rewards"
Participation in app development	1	1.69%	Possibility to take part in app development	-"possibility for everyone to code on app"
New possibilities to measure vital parameters	1	1.69%	New possibilities to measure vital parameters (body implants)	-"sensors inplanted into the body transmit data to smartphone app"
Non-responses	14	19.18%	Question not answered	N/A, blank, unrelated, illegible etc.
N=54 Total responses: 73 Total pos. control beliefs responses: 59 Average # responses/participant: 1.09				

Table 6: Overview of positive control beliefs

In terms of negative control beliefs the study elicited 67 beliefs. Some beliefs were basically the negative formulation of the positive belief controls (e.g. app is too complicated/not easy to

use, low quality of app, specific feature not available). Top three mentioned barriers are a low quality of an app, the absence of a suitable smartphone and a high complexity of the app. For details see table 7 below.

Theme	Frequency	Percentage	Description	Example quotes
Low quality of app	13	19.40%	Low quality of app (e.g. design, added value of features, calculations, stable operation, battery and data volume consumption)	-"less or no updates" -"Poor design" -"If they would massively use smartphone battery" -"Poor application (e.g. menu navigation, features, etc.)"
No/broken or not app-compatible smartphone	11	16.42%	Presence of smartphone that is compatible to med. app	-"my smartphone has e.g. no NFC function" -"if apps are only available on certain operating systems" -"No smartphone"
High complexity of app	9	13.43%	App is too complicated to set-up and/or use	-"Complicated applications" -"Complicated set-up" -"if apps are too complicated to use"
Specific feature not available	8	11.94%	Specific feature is not available in app(s)	-"If there would be no voice command since manual data input is difficult at some days" -"no data analysis possibilities" -"No Accoustic reminder"
Data privacy is not ensured/ Fear to lose control of personal data	6	8.96%	Data privacy is unsure	-"No control over my data" -"data privacy must be ensured" -"if they would request a lot of personal data"
No or low internet connection	6	8.96%	No or low internet connection makes app usage difficult or impossible	-"Poor mobile internet connection" -"No internet connection"
App is not free of charge/is too expensive	5	7.46%	App is not free of charge/is too expensive	-"Higher costs or subsequent costs" -"Expensive in app store"
Personal circumstances	2	2.99%	Personal circumstances (e.g. physical and/or mental restrictions)	-"physicial and mental limitations" -"If I cannot concentrate anymore"
Difficult or no compatibility of apps with medical device	2	2.99%	Difficult or no compatibility of apps with medical device	-"Difficult pairing with device, if necessary via Bluetooth or Wifi"
Change of political direction	1	1.49%	Change of political direction	-"Political swing to the right"
App data is given to health insurance	1	1.49%	App data is given to health insurance	-"Feedback is given to health insurance"

Less functionality due to external factors	1	1.49%	Less functionality due to external factors (high data privacy regulations)	-"Functional restrictions due to external factors (Data privacy)"
No test version of app is available	1	1.49%	No test version of app is available	-"No test version of app available"
Physician is against app usage	1	1.49%	Physician is against app usage	-"physician advices against app usage"
Non-responses	15	18.29%	Question not answered	N/A, blank, unrelated, illegible etc.
N=54 Total responses: 82 Total neg. control beliefs responses: 67 Average # responses/participant: 1.24				

Table 7: Overview of negative control beliefs

Summary of salient beliefs

In total respondents mentioned 159 behavioral beliefs, 47 normative beliefs and 126 control beliefs. Having them analyzed by means of a content analysis the following table summarizes the three most frequent mentioned salient beliefs per category.

	Advantages	Disadvantages
Behavioral Beliefs	1. Higher comfort/ease of use 2. Support in daily disease management 3. Increased control over disease	1. Data privacy is suspect 2. Dependency on app 3. Data loss in case of damaged or lost smartphone
Normative Beliefs	Approvers	Disapprovers
	1. Physicians 2. Personal environment 3. Health Insurance	1. Physicians 2. Other chronically-ill people 3. Personal environment
Control Beliefs	Facilitators	Barriers
	1. Availability of specific feature 2. High usability/ease of use 3. Device compatibility	1. Low quality of app 2. No/broken or not app-compatible smartphone 3. High complexity of app

Table 8: Most frequent salient beliefs about using mHealth apps

5   Discussion

Theoretical contributions

In General, this study elicited a variety of beliefs in regard to the use of mhealth apps, forming a more precise picture of what German patients with chronic conditions think about medical apps. The majority of study participants is already using medical apps and see more advantages than disadvantages of the use of medical apps (on average 2.04 positive behavioral beliefs compared to 0.9 negative

behavioral beliefs were mentioned per respondent).

The most frequent mentioned advantage of mHealth apps was the high comfort that apps offer. Especially in comparison of having a handwritten documentation, apps save time, are always at hand, offer very good graphical representations of the values, and provide a good overview of all (history) data. The perceived ease of use of mHealth apps is very high among study participants. In regards to second most mentioned advantage, the support in daily disease management, participants answered that medical apps are a great help in administrating the disease. For example, patients see an improvement in their medication management. Typical use cases in regard to medication management with medical apps are: the set-up of reminders, having an overview of all the drugs that can be shown in case of emergency, in pharmacies, and during physician visits, calculation on the time to refill medication, connection to care-givers/family to track if the patient has taken medication. Especially for older people and people having to take numerous drugs over the day medication reminders are a very valuable tool. A feeling of increased control is caused by having the data present all the time and structured in a better way. The second and third most mentioned advantages, namely the (administrative) support in daily disease management and the increased control over the disease are both items that mirror perceived usefulness of the mHealth app usage.

Noteable is the data privacy concern, the most frequent negative behavioral belief. Participants remain uncertain about the app producers' behavior and have doubts on whether their data can be accessed and used in ways they are not aware of. In other areas where personal data are used to perform online services as online shopping and online banking, researchers have included the variable trust, percieved risk, or privacy concerns in their

research (e.g. Dinev & Hart, 2006; Gefen, Karahanna, & Straub, 2003; Kim, Ferrin, & Rao, 2008; Shumaila, Foxall, & Pallister, 2010). In regard to mHealth research privacy concerns have not been examined to that extent. Guo et al. (2016) investigated the privacy–personalization paradox in mHealth, the paradox of consumers wanting to utilize personalized services, while at the same time being reluctant to disclose personal information or at least wanting to reveal as little information as possible. The study's results showed that privacy concerns are negatively associated with trust and behavior intention, which will negatively affect customer's acceptance of mHealth services. The result of this elicitation study could affirm researchers to have a closer look on data privacy concerns as an influence factor of mHealth adoption in future research, especially if research focuses on German patients.

As expected there are a few stakeholder of healthcare systems that could have normative influence on the adoption of mHealth. Results show that physicians are the most frequent mentioned group that could influence respondents' use of mHealth apps in both, positive or negative direction. Next to the physician, persons from the closer personal environment are mentioned to influence patients as well as the health insurance or other people with chronic conditions. This study gives rise to consider social norms as influence factors on adoption more thoroughly in the context of healthcare in future research.

The salient control beliefs identified in this study can be divided into two dimensions. On the one hand facilitating conditions, relating to such factors as time, money and resources. On the other hand the study revealed control factors relating to the internally based concept of self-efficacy (Bandura, 1977) that is also used in the TPB. The positive control belief of a high usability as an enabling factor as well as the negative control belief of a complex app can

both be assigned to the self-efficacy dimension. Both refer to the perceived ease or difficulty of performing the behavior. Respondents speak of "intuitive usability", "easy user guidance", "ease of use" and "easy handling", showing that they have a strong need to easily and quickly understand the app's handling after starting to use it. Patients may feel unable to use a too complex medical app. Facilitating conditions are external factors as the presence of specific features, device compatibility, a high app quality and the access to a functional smartphone.

In summary, this study contributes to theory by showing that elicitating salient beliefs as a pre-study is useful as a variety of beliefs from the target group were identified. The number and variety of mentioned beliefs show that doing a belief elicitation study via an online survey is feasible. Former research by Petkova, Ajzen, & Driver (1995) showed that the 12 most frequently elicited beliefs were significantly more strongly related to attitudes than the 12 least frequently elicited beliefs. Taking this relation into consideration the salient beliefs towards mHealth apps can be used as basis for further research.

Managerial recommendations

From a practical point of view the study provides some interesting points for app producers that could be taken into consideration to increase the user base and satisfaction with the app.

1. The most frequent mentioned enabling factor (positive control factor) is a specific feature requested by respondents (e.g. accoustic reminder, scan of medication, possibility to share data with physician). This shows that patients are well aware of their needs in regards to the disease. As with every product development it is essential to integrate the target group in the product development process to best meet their needs.

2. Data give the presumption that male patients consider the physician as a positive influence factor for their use of medical apps more frequent than female patients (47% of all participating men mentioned physician compared to 26% of all female participants) rising the question if men need more an external source of influence to change behavior than women. In regard to sport activities a study revealed that men were more motivated to do sports when the activity included some performance factor (Castillo, Duda, Balaguer, & Tomás, 2009). The physician might be that factor controlling behavior in form of checking results during regular patient visits. Independent from possible gender differences the physician has been identified as an important influence factor on the use of medical apps (positively as negatively). Therefore, app producers should think of how to include physicians in the product development and marketing efforts.

3. Insecurity in regards to data privacy is the most often mentioned negative behavioral belief of respondents. App producers should clearly state where and what data are saved and if data are used for any purposes or given to third parties. By having a very transparent communication app producers could give patients more security and might convince more patients to use the app.

4. Respondents who are currently not using a medical app disproportionately often stated the dependency on the app as a negative behavioral belief. Participants see it as a risk to rely too much on the apps and to lose the natural perception for the disease and the body when they get used to them. App producers could try to strengthen the positive belief (that was also mentioned by 6 respondents) in the communication where patients mentioned that disease patterns where identified in the process of app usage.

5. Ease of use and along with device compatibility is a very important control

factor. App producers should foster cooperations with medical device producers or at least try to enable device compatibility with a variety of medical devices. Cooperations with big device producers could also be a good marketing tool for medical app producers.

Limitations

In General, the study is of qualitative nature, therefore it only shows tendencies and does not allow for any statistical statements. One limitation of the study is, that the ratio between user and non-users of health apps was very unbalanced (over 75% of study participants use health apps). The picture might be different when the share of non-users would be increased. Another limitation is that participants have been recruited solely in online channels, leaving out the group of patients that are not present in the online world. Moreover, it can be assumed that those people exchanging in online disease groups are quite open for technology in general which might result in skewed attributes of the online population.

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8　Appendix

Topic	Question	Answer Type
Survey Selection Criteria	Do you have a chronic disease (e.g. diabetes, hypertension, chronic back pain, COPD)?	closed question
Medical App Usage	Do you use one (or more) medical apps or have used it in the last 12 months?	closed question
General App Usage	Do you use other apps on your smartphone and if yes, how often?	closed question
Behavioral Beliefs (advantages)	What do you believe are the advantages for you when using medical apps?	open question
Behavioral Beliefs (disadvantages)	What do you believe are the disadvantages for you when using medical apps?	open question
Behavioral Beliefs (other)	Is there anything else you associate with using medical apps?	open question
Normative Beliefs (approval)	Are there any individuals or groups who would approve of your regular use of medical apps?	open question
Normative Beliefs (disapproval)	Are there any individuals or groups who would disapprove of your regular use of medical apps?	open question
Normative Beliefs (other)	Are there any other individuals or groups who come to mind when you think about using medical apps?	open question
Control Beliefs (enablers)	What factors or circumstances would enable you to use medical apps?	open question
Control Beliefs (inhibitors)	What factors or circumstances would make it difficult or impossible for you to use medical apps?	open question
Control Beliefs (other)	Are there any other issues that come to mind when you think about the difficulty of using medical apps?	open question
Demographics	What is your gender?	closed question
Demographics	What is your age?	closed question
Demographics	What is your disease?	open question

Appendix 1: Questionnaire used in study, Original language: German