A Healthy Lifestyle and the
Adverse Impact of its Digitalization:
The Dark Side of Using eHealth Technologies

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Abstract. eHealth technologies strongly influence healthy lifestyles. In addition to numerous advantages and positive effects, we analyze adverse effects of technologies that are used in everyday life to support a person's health or health management. Therefore, we conducted short interviews and a literature review to structure aspects of a healthy lifestyle in eight areas related to the potential technology usage. Based on that, this contribution presents a systematic collection of negative effects of eHealth technologies on end users or patients. With regard to our results, this contribution provides seven scientific and six practical implications.

Keywords: eHealth, healthy lifestyle technologies, adverse impact, digitalization.

1   Introduction

The perception and thinking about which factors affect human health has changed fundamentally over the last 40 years [1]. The healthy lifestyle is one of eight megatrends in Europe to 2030, making it "a shift in […] [behaviors] or attitudes that has global impact and crosses industries" [2]. Health is an important value for German people and is ranked second in the value index 2019 [3]. Regarding the areas that belong to a healthy lifestyle, the scientific literature has focused on nutrition and physical activity until the turn of the year 2000 [4]. Often health was associated with external appearance such as body weight [5]. However, the complexity of health was not taken into account. Other areas such as mental and social aspects have an impact on a healthy life alike [1].

Besides economic power, population and values change as well as environmental changes and burdens, technology is a driver that leads to long-term shifts in behavior and attitudes [2]. In recent years, there was a critical mass of international evidence reporting on the increasing interest and use of smartphones, mobile applications (apps), social media and wearables on health-related topics. Especially among young adults, these technologies strongly influence lifestyle behaviors [6]. Thus, knowledge and behavior in healthy living shifts by using technologies. As a result of digitalization, health and medicine are increasingly becoming an integral part of

everyday life [6, 7]. The digitalization and use of technology in a healthy lifestyle should support people to live this lifestyle in an easier way. Because of accessibility, diversity and details of health information, technologies can be used to gain a better knowledge of the body, diseases and health prevention as well as to maintain a better health status [8]. Often technologies are only dealt with demonstrating or investigating their usefulness, opportunities, or advantages [7, 9]. Goodyear [5] notes a lack of empirical evidence on the experience and usage of technologies such as fitness trackers in the domain of healthy living for young people, especially on potential negative effects. In scientific contributions on new digital solutions, adverse impacts on humans are only briefly mentioned or discussed with focus on certain cases like a specific eHealth technology.

This contribution provides a framework of the potential use of technologies in healthy lifestyle. Based on that, we present a structured collection of negative effects of healthy lifestyle technologies for the end user or patient, such as fitness trackers or health apps. For this purpose, our work is guided by the following research questions:

1. **In which areas of a healthy lifestyle is digitalization applied?**
2. **How can healthy lifestyle technologies have adverse impacts on people?**

To answer these research questions, we organized our contribution as follows: In order to approach the subject of health holistically, we structured areas of a healthy lifestyle after surveying 70 people. We asked them about areas that they see as a part of healthy living and the possibility of using technologies in these areas. In some short interviews, discussions arose about the negative effects of these technologies. Afterwards, we conducted a systematic literature review with regard to adverse impacts of using technologies in each identified healthy lifestyle area.

2 Methodology

Several adverse effects of using eHealth technologies or technologies for a healthy lifestyle are mostly mentioned while examining for example positive effects or the acceptance. This research gap motivated us to focus on the structured research of these negative effects. Therefore, we (1) structured the topic healthy lifestyle and its use of technologies, which deal with the first research question. Furthermore, we (2) investigated adverse impacts of using technologies in these areas in relation to the second research question. Thus, the first section of the results presents a prerequisite for the literature review in the second part of this work: the holistic consideration of the potential adverse effects of eHealth technologies.

First, we carried out short interviews with 70 participants from Germany in different locations. The first question was purposely chosen independently of technology usage in order to provide a holistic view on the topic health to the respondents. Otherwise, the given answers might be biased by the existent knowledge about eHealth technologies. In this example, the respondents might answer that only physical activity and sleep are relevant for tracking because their fitness trackers are able to analyze these data. First, we asked the participants about their demographics, which can be retraced in Table 1. Then, the interviews were structured with two

questions to categorize healthy lifestyle areas holistically: (1) Which specific factors or areas have an impact on a healthy lifestyle? (2) Can you imagine using technologies in each of these areas?

Table 1: Demographics of the participants

Attribute		Total	%	Attribute		Total	%
Age	18-29	38	54%	*Gender*	Male	42	60%
	30-39	14	20%		Female	28	40%
	40-49	7	10%	*Residence*	Town	47	67%
	>50	11	16%		Village	23	33%

With regard to the answers to the first question, the level of detail ranged from three to 20 mentioned categories or factors of a healthy lifestyle. In addition, we identified healthy lifestyle areas from literature in the field of digitalization and business informatics to verify the interview results. These listed various lifestyle factors in relation to digitalization. With our domain knowledge, we independently used all identified categories of a healthy lifestyle from the interviews and literature to derive clustered healthy lifestyle areas. After the short interviews, discussions with respondents erupted, in which the negative effects of using technologies were also mentioned.

Table 2. Keywords and relevant findings in the context of systematic literature review

Domain	Keywords				
Adverse impact	adverse impact, adverse effect, risk, consequences, disadvantage, problem, challenge				
Digitalization	Digitalization in health, digital health, eHealth				
Healthy lifestyle area	**Keywords**	**db1**	**db2**	**db3**	**db4**
Physical activity	physical activity, movement, fitness, exercise, motivation, wearables	5	6	2	8
Nutrition	nutrition, diet, food	0	0	2	5
Mindset	work-life balance, mental health, stress management, satisfaction, lifestyle, nature, targets, incentives, internal drive, nature, finance	1	2	1	4
Social aspect	social environment, social life, social surrounding	2	3	2	8
Addiction prevention	seeks prevention, addiction, drugs, smoke, alcohol	2	1	1	5
Sleep	sleep, recovery, relaxation, recreation, sleeping rhythm, meditation	3	5	1	4
Healthcare	healthcare, illness, sickness, disease, prevention, quantified self	6	2	2	8
Health literacy	health literacy, health competency, health education	2	1	3	2

We conducted a systematic literature review according to vom Brocke et al. [10] with different search terms in four databases: SpringerLink (db1), PubMed (db2), ScienceDirect (db3), and Google Scholar (db4). Since the literature review for adverse impacts of the digitalization in healthy lifestyle would be quite unspecific, we categorized our research along keywords of the areas of healthy living as derived from the interviews (cf. Table 2). Each of our search terms consisted of a variation of several keywords from one *healthy lifestyle area* and from the domains *adverse impact* and *digitalization*. Table 2 presents the keywords and the number of relevant contributions, which are identified in the literature review. First, we assessed the relevance of the studies on the basis of the titles and abstracts. Afterwards, we analyzed the full text of selected contributions with the following selection criteria: (I) the content of the abstract contains at least one adverse effect in relation to using eHealth or healthy lifestyle technologies, (II) the contribution was a conference paper or journal article, and (III) was published after 2013. Due to the Quantified Self movement, which was "at the center of consumer interest and industry attention in the wearable tech industry" in 2014 [11], we focused on more recent articles.

3   Results

3.1   Potential areas for the usage of healthy lifestyle technologies

In this paper, the understanding of health is broader than just physical health. The WHO defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [12]. In order to analyze structurally different healthy lifestyle areas, in which technologies can be used, we divided a prototypical healthy lifestyle into eight different areas based on our interviews and literature (cf. Figure 1). In the following part, we describe these lifestyle areas and point out the relation to Maslow's levels of hierarchy of needs, which concentrates on the development of healthy individuals [13]. As a result, Figure 1 shows by which levels of needs each identified area is addressed and that each level of needs was covered. Needs in the hierarchy can be basic needs (1. physiological, 2. safety, 3. love/belonging, or 4. esteem) or growth needs (5. self-actualization) [14]. With regard to our interviews and in combination with literature results, all these identified categories contribute to the fact that humans feel healthy.

In Figure 1, we also show the most relevant of the participants' mentioned keywords within each category. Just 35% of respondents directly associated **healthcare** with a healthy lifestyle, which is related to Maslow's second level. This might be due to the aspect mentioned by one participant: "Those who live a healthy life do not need healthcare". The answers in this area contain medicine, advice from health professionals or self-healthcare due to prescription-free and alternative medicine. Referring to love and belonging of the third level in Maslow's hierarchy, the **social** aspect was an important factor for the majority of respondents. It was mostly mentioned at least in third place, including the keywords friends, partners and a stable and positive environment. In order to outline the social aspect, in literature,

some authors stated social support and environment and life situations, such as workplace and neighborhood [7, 15]. 64% of the participants regarded **sleep** as an important issue to maintain their health. Maslow defines sleep as a physiological need. Lappalainen et al. [16] illustrates that sleep depends on other lifestyle factors such as working hours and perceived stress.
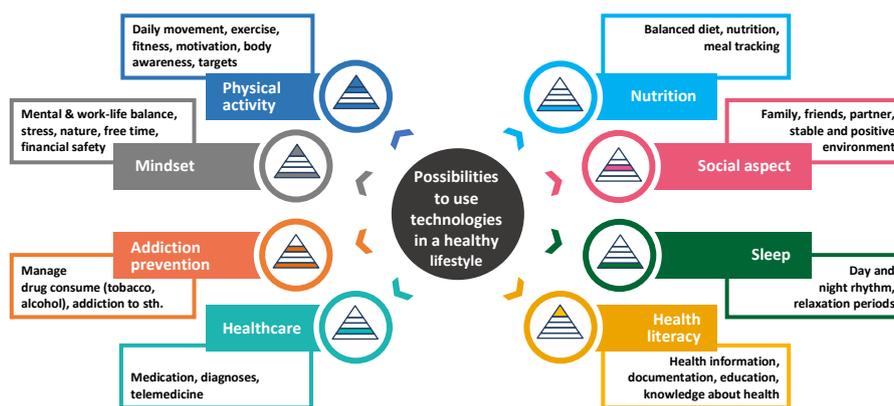

Figure 1. Identified healthy lifestyle areas related to the potential technology usage

In the context of **addiction prevention**, the perceptions from literature and interviews partly diverged. On the one hand, scientific literature and half of the respondents insisted that drugs such as alcohol should be avoided for a healthy lifestyle [15]. On the other hand, the opinions supported a controlled drug use to a small extent or alcohol consumption management [16, 17], rather than strictly avoiding it. The reason for this is that they associate fun and pleasure directly with the consumption of drugs, which is more than a physiological need. In turn, it promotes mental health and refers to the fourth level of Maslow's hierarchy: freedom.

The area **physical activity** refers to movement in leisure time and work as well as motivation to increase physical activity [16]. Physical activity can be seen either as a physiological need or as a passion in case people solely practice for their external appearance (level 1, 4, and 5). Another physiological need is **nutrition**, which covers the subjects of balanced diet and the amount of consumed food. The area **mindset** mainly consists of the mental attitude and psychological experiences. In addition, literature proposes energy, internal stress, absence of depression and emotions as important factors [6, 17], whereas respondents cited aspects such as work-life balance, stress management, experiences in nature, personal and professional goals, and self-love. These aspects cover level 5 in Maslow's hierarchy of needs, pursuing one's passion and aims. Furthermore, some participants explained that a healthy mindset requires a minimum of budget to cover basic needs. We regard the financial aspect as a security need, as proposed by Maslow. In literature, **health literacy** was associated with health awareness and better knowledge about body, illness and healthcare (level 5, knowledge and interests in context to self-actualization). Throughout the interviews, health education and awareness about one's own body

were identified as a relevant part of health literacy. In literature, health literacy is the understanding of "relevant health terms and place health information into the appropriate context in order to make appropriate health decisions" [18]. Taking eHealth literacy into account, it represents "the ability to seek, find, understand health information from electronic sources and apply the gained knowledge to addressing or solving a health problem" [18].

3.2 The adverse impacts of using healthy lifestyle technologies

The main purpose of our work is to identify potential adverse impacts of used technologies in a healthy lifestyle. Digital health involves the use of technologies to provide information, improve health literacy, and support people in their health and disease management [7]. In our findings, we do not concentrate on general negative impacts of technologies on human health, e.g. resting for too long. In literature, general negative effects of digitalization have already been extensively discussed and have been recorded by the WHO [19], among others. In our contribution, we focus on the adverse effects of healthy lifestyle technologies on people, not necessarily on their health. Based on their function and information, these technologies are associated with a healthy lifestyle such as eHealth technologies. The term *healthy lifestyle technologies* is used to summarize technologies that are used to manage health in a person's everyday life. They are used to support their health or health management. In our results, these technologies range from smartphone applications, health related websites, and social media with health content to wearables such as camera clips, sleeping trackers, smart watches, and smart clothing, which are able to generate an electroencephalogram and measure location, temperature, or pressure [7, 20]. Currently, there is a trend to quantify the own body and surrounding metrics to improve oneself [21]. One in six people in the US currently uses wearables [20]. These people like to quantify themselves measuring their workout, daily activity, sleep and more. However, bio-monitoring and self-tracking technologies as well as other healthy lifestyle technologies may have various unfavorable effects [22].

Our systematic literature review revealed a variety of adverse effects on human beings dealing with the use of eHealth technologies. Table 3 summarizes these potential negative impacts. If we could allocate some of the aspects to various areas, we subordinated it to the most appropriate area. Every mentioned healthy lifestyle technology possesses one commonality: the highly discussed matter of **data protection and privacy** of the personal data [11, 23] that is most likely to be assigned to the area *social aspect*. The exchange of personal data is a very sensitive issue for users, for example the continual reporting of the location or in particular the collection of health related data [11, 24]. There is need for more private data and confidentiality protection [25]. Nowadays, wearables are able to monitor several medical risk factors [20]. Fitness trackers are not subject to the same protection concept as other medical applications, although the collected data have the same sensitivity. Wearable manufacturers are able to classify their devices as healthy lifestyle technologies that are not subject to stricter rules like medical technologies [26]. This results into health data being inadequately protected. In this case, it could

be difficult if the privacy of consumers was violated. Regarding data privacy statements, the younger generation has alarming points of view suggesting that nobody is interested in their information anyway because there is supposedly enough other personal information on the internet [7]. Health as well as other personal information may be used for discrimination and surveillance *(I4.5)*. Digital health surveillance systems, e.g. health insurance companies, are able to gather more details about the population down to each individual [21].

A negative impact of self-tracking **physical activity** is that the human body is regarded as a normalized object rather than a human subject. Users of fitness or health wearables may no longer rely on their sensitivity, but on their set goals and ignore physical warning signals *(I1.1)*. Supposing a user is in a bad physical condition, he gets informed by his fitness tracker, that in order to achieve the daily fitness goal he needs to proceed walking another 2000 steps nevertheless. The user would have to ignore his physical condition in order to reach the fitness goal. This initiates a process, in which users become less conscious and miss the deep understanding of their bodily reactions and feelings. They lose their awareness of body sensation such as muscular sensations *(I8.5)*. As a result, health literacy suffers [5, 22]. Stress can occur due to a lack of **health literacy** or information overload without precise guidance or explanation *(I8.4)* [27]. In this context, data is not useful for these users because it offers too little information. Some consumers do not know how to interpret data such as their heart rate [28]. One participant mentioned that he is unsure about whether his daily target step amount is appropriate for him. This aspect goes along with the fact that wearables can cause the anesthetization of the human sensation and experience [22]. One participant stated: "Nowadays, it seems so, instead of having fun while exercising or trying out good feeling activities, the next fitness or diet program via internet is used to get slimmer and fitter".

In general, there is a lack of trust in wearables [25]. Collected data e.g. from fitness trackers are not always accurate *(I1.2)*. When consumers notice the difference between the actual behavior and the recorded data, general mistrust in eHealth technologies occurs. Partly, this leads to an abandonment of usage [22, 28]. In the context of **sleep** analysis, lifestyle technologies do not have the advanced maturity and accuracy like technologies in sleep centers. Fitness trackers rather determine the waking and sleeping times, although they show the user the exact sleep phases. However, there are irregularities, for example, if users do not move while awake [29, 30]. The analyzed sleeping phases of trackers for lifestyle purposes are rarely reliable *(I6.1)* [29]. Thus, users may perceive days or nights worse with an evaluation of wearables than without, and vice versa [5].

In general, the principle of self-tracking is based on self-improvement, whereupon one feels the urge of further advancing this process. Thus, the consumer will never attain an optimum *(I1.4)* and will never be satisfied with his current performance status [22]. Extending user's sport to eHealth technologies, the enjoyment of the workout and positive **mindset** can be diminished *(I3.2)*. Users may not achieve a mental balance, which usually occurs during training [5, 22]. In order to wear a smart watch while doing sports, one participant of our interview mentioned "users are mostly more focused on their performance than on the surrounding and the enjoyment

of training". This can also be described as an absence of the usual effect of mental balance, as the feedback from technology disrupts the flow of thoughts *(I3.1)* [22]. Users feel demotivated and get internal stress, when failing to reach their daily target [5, 16, 17]. The same effect occurs when the users' performance drops *(I1.3)* [31]. Further, people may switch to sports in virtual reality such as immersive technologies or fitness platforms via video. In this context, participants mentioned that while exercising via the fitness platform, no expert is able to verify the correct execution of the users' fitness exercises *(I1.5)*.

Table 3. Potential negative impacts of healthy lifestyle technologies

No.	Impact
1	**Physical activity**
1.1	Ignorance of physical warning signals to achieve set daily goals [5, 22]
1.2	Mistrust because of low accuracy of fitness trackers [22]
1.3	Demotivation through performance drops [31] and non-wearing [32]
1.4	Continuing self-improvement, so the user never attains an optimum [22]
1.5	No verification of the correct execution of fitness exercises (interview)
2	**Nutrition**
2.1	Low eHealth readiness (insufficient cooperation betw. dietitians & IT-experts) [33]
2.2	Weight loss as a result of self-tracking practices [5]
2.3	Increasing association of health with external appearance [5]
3	**Mindset**
3.1	Dissatisfaction, bad mood and mental disbalance might be promoted [5, 22, 34]
3.2	Diminished enjoyment of the environment or of the activity [22]
3.3	Constant or on-call availability [35]
4	**Social aspect**
4.1	Social pressure in relation to negative judgement of other users [31]
4.2	Obligation to purchase [36]
4.3	Inferiority feeling because of social networks such as Instagram [37]
4.4	Inadequately protected data can be used for discrimination and surveillance [21]
5	**Addiction prevention**
5.1	Dependence on feedback [38]
5.2	Addiction to eHealth technologies [32]
5.3	Encouraging controlling behavior of other people [9]
6	**Sleep**
6.1	Fluctuating reliability on sleep phases analysis [29]
6.2	Rather trust their data as body feeling [5]
6.3	Lower sleep quality when using apps before bedtime [39]
7	**Healthcare**
7.1	Inequalities between users and non-users [8, 40].
7.2	Disparities among healthcare providers [8]
7.3	Misdiagnosis because of self-diagnosis [25, 41, 42]
7.4	Self-tracking can be tiring [43]
7.5	Price discrimination in tariff conditions based on tracked health data [24, 44]

8	**Health literacy**
8.1	Less need to acquire knowledge due to access to the internet [45]
8.2	Challenge to find and interpret reliable and appropriate health information [46]
8.3	No validation of online information [47]
8.4	Stress without precise guidance or explanation [27]
8.5	Less awareness and interpretations of bodily reactions and feelings [5, 22]

In times of social media, influencers set trends also in terms of a healthy lifestyle. Fitness and **nutrition** become increasingly important within social media. Health is increasingly associated with the outward appearance as well as body weight *(I2.3)* [5]. During training or at the end of the day, **social** pressure may arise from continuous comparisons being made of own results or of those from other users. Users are afraid of negative judgements from others *(I4.1)* [31]. In social media, people follow different profiles that contain healthy content, which may present solely highlights. A feeling of inferiority or a dependence on this content can occur *(I4.3)* [37]. Besides the **addiction** to content, users can become addicted to wearing eHealth technologies or on the feedback such as on their results or vital parameters *(I5.1-2)* [32, 38]. This addiction, as a behavior shift, is the interest of the manufacturers, who invest much effort into their social influence strategies [20]. Some consumers feel incomplete after putting down the device [22]. Besides a dependence on own data, a controlling behavior over other people can occur [9]. In this context, health wearables might be misused for other purposes, such as monitoring employees, children or partners. Some apps already exist on the market to control and influence other people, e.g.: sleep, school and internet down time can be set and certain websites can be blocked [48].

The healthcare sector is also subject to major changes through digitalization. Due to the constant data resulting from the monitoring of the body, the concept of the "digitally engaged patient" implies a shift of responsibility from the service provider to the individual [8]. Despite efforts to promote eHealth for everyone [18], following inequalities between users and non-users of information technologies in healthcare occur, especially since the use of quantified self apps *(I7.1)* [8, 40]. Consumers benefit from the ability to store and retrieve health information, schedule appointments with healthcare providers easier, and simplify **healthcare** processes. One of our interview participant mentioned that "health must always be accessible to all, even those who are less educated or have less technology skills". The internet provides a flood of information for everyone [46]. This complicates the search and interpretation of reliable and appropriate health information *(I8.2)*. Not merely the age, but the educational level in particular is a crucial factor in seeking health information [49]. Websites and social media consist of some fake and not reliable content about, among other things, health, nutrition and sports [37]. Moreover, online forums provide answers regarding health-related questions from people with little health competence. These may give wrong advice or discuss the seriousness of health problems instead of offering a solution *(I8.3)* [47]. When dealing with diseases, self-diagnosis is a dangerous concept and might lead to misdiagnosis *(I7.3)* [41, 42]. One reason for this may be that patients describe or report their symptoms incorrectly [25,

42]. Besides inequalities among patients, there are also disparities among healthcare providers *(I7.2)*. They do not have the same prerequisites for their business without eHealth such as telemedicine [8]. In addition, on the one hand, digitalization provides flexibility to many professionals, e.g. doctors. On the other hand, it leads to the expectation of constant or on-call availability. The supposedly positive effect of flexibility can shift to a continuous massive stimulus flooding and stress. The associated overload of the brain can disturb the work-life balance *(I3.3)* [35, 50]. A feeling of control, accuracy and the lack of privacy may cause dissatisfaction and bad mood *(I3.1)* [5, 22, 34].

4   Discussion and implications

While, in general, digitalization leads to less physical activity [35], eHealth technologies motivate users to increase physical activity as well as their health literacy and competence [51]. Fitness trackers are intended to motivate the user to exercise more by measuring vital parameters and creating a sense of achievement by setting and achieving goals [7]. In turn, this results in less health risks such as coronary heart disease, overweight or obesity, certain types of cancer and mental disorders [35]. Further, due to eHealth technologies, location barriers are bridged and health information can be shared and accessed anywhere. In addition to these benefits, consumers should also consider negative effects, as our results show (cf. Table 3).

	Physical activity	**Social aspect**	**Sleep**	**Addiction prevention**
Enabled by technology	Continuous tracking of vital parameters	Comparisons with own results and with those of other users	Tracking of sleep phases	Addiction management
Potential negative impact	Increasing trust in data rather than in body sensation	Social pressure and feelings of inferiority occurs	Incorrect measurement due to the lack of maturity	Encourage controlling the behavior over other people

	Healthcare	**Mindset**	**Health literacy**	**Nutrition**
Enabled by technology	Self-healthcare and -diagnoses, health management	Constant availability and feedback	Easy access to health information	Diet management
Potential negative impact	Difficulty to find reliable and appropriate information	Mental balance is disturbed and stress occurs	Loss of awareness in terms of body sensation and reaction	Increasing association of health with appearance

Figure 2: Key adverse impacts of technology usage for each healthy lifestyle area

Considering these adverse impacts, we recognized a strong connection between the different areas of a healthy lifestyle. We identified wearables as the most relevant and discussed technology. Not least for this reasons, it is of great importance to us to identify our healthy lifestyle areas in order to approach this topic holistically. Throughout targeted search for each of the eight areas, we were able to record and to discuss a variety of results. Otherwise, the results might be unidimensional due to the fact that they mainly contain aspects about physical activity. There is a trend in quantifying everything along the areas quantified self, smart cars, houses and clothes [21]. In relation to the adverse impacts of healthy lifestyle technologies, we recognize some major aspects. Based on the structure of the eight areas of healthy lifestyles, Figure 2 presents not only the main opportunities for technology usage in each area

but simultaneously also the biggest potential adverse effect on users. This demonstrates the unfavorable direction in which lifestyle can be shifted due to the use of healthy lifestyle technologies. Especially stress is an always-reoccurring factor as a result of either addiction to the feedback, not-reaching set goals or comparison to other users. We can derive implications for actions on both sides: practical implications (PI) for several health providers and eHealth manufacturers as well as scientific implications (SI) for further research.

In the healthcare sector, there is a major change resulting from digitalization: the shift of responsibility from the service provider to the individual [8]. In Germany, the Bundestag passed a law for an improved supply through digitalization and innovation (Digitale-Versorgung-Gesetz, DVG) on 7th November 2019. This enables prescription apps, the simple use of video consultation and enabling access to the secure data network during treatments [52]. Before eHealth applications can be applied in the individual medicine sector, they have to undergo further improvements. A lot of health information is a prerequisite in order to analyze the data properly. Each individual diagnosis needs to be based on the own health data with a reference to population statistics. Otherwise the own health data are only random information [21]. As a result, to ensure the quality of online diagnosis applications or other apps based on analyzing health data, it is important to collect a vast database, creating a health reference point based on population statistics (**PI1**). This must be adhered before an application makes any diagnoses or a physician supports an application via prescription. Misdiagnoses can occur, if the data basis is insufficient. However, this and other eHealth applications only succeed if there is a clear guidance on the eHealth technology and its content. This is particularly necessary for people with little health or digital competence as for example older people [43]. In the context of health literacy, there is a need to establish an understanding that being fit is more than being not fat or that being healthy is not equal to the norm of taking 10.000 steps a day [5]. For example, some users do know that they have an heightened heart rate but they do not know the meaning of a heightened heartrate [28]. In another way, more information in eHealth applications would help to interpret the presented data, e.g. about symptoms or therapies (**PI2**). It might be beneficial to integrate methods such as gamification, increasing health knowledge or understanding the full functionality of apps. Further research is needed to build concepts such as gamification into health application, e.g. fitness tracker (**SI1**).

A recurrent problem is the protection of sensitive health data. Medical applications are subject to a special protection concept. Currently, most fitness trackers are not classified as a medical application and thus they are not subject to this strict protection concept. In the future, technologies in relation to the collection of health relevant data should be monitored and classified by whether the collected information is medically relevant or not and therefore has to be protected [26]. It may be a solution to classify wearables and applications more strictly. With regard to the protection concept, healthy lifestyle technologies might be ranked as medical devices as soon as they handle personal health data (**PI3**). It may be reasonable for fitness trackers to be classified as medical devices if physicians want to refer to the measured vital parameters in their consultation, e.g. via electronic health records. A related

issue is the validation of information, either from friends or from the internet [46]. In context of applications, which are only presenting impersonal information, there is a need for a standardized certificate to ensure that eHealth applications can be trusted the information's correctness and validity **(PI4)**. One solution might be that this certificate can only be awarded if professionals validate health information. Through the ability to prescribe apps with regard to the law DVG, physicians have to be able to trust the application because of mentioned standardized certificates.

Patients prefer self-management of diseases in connection with telemonitoring rather than visiting a doctor [43]. There are inequalities of users and non-users of eHealth applications because of their skills in respect of technology usage. Health must always be accessible to everyone. As a result, in future, an analogous solution must still be available for when it shifts more to the usage of online applications **(PI5)**. While the documentation with technologies for diseases promises enormous simplification and benefits [8], self-diagnosis is usually risky, especially for newly occurring symptoms. Some physicians perceive digital health as a threat because it undermines the high reputation of the medical profession and the asymmetry of the physician-patient relationship [8]. Within conceptual and practical differences, the boundaries between the individual and the population, personal and public health, surveillance and healthcare are blurred [21]. We argue that digital health should be seen as an opportunity to support diagnosing and treating diseases and early detection and prevention of diseases. Further research on future collaboration or extension of health care professions with technologies is needed. One potential research field is whether artificial intelligence is an opponent or opportunity for professionals in the matter of diagnosis or information **(SI2)**.

Personal health information is a sensitive issue also for users of wearables. In case of continuous self-tracking, the consideration of the individual rights is a crucial challenge [11]. With regard to the use of personal data, the health providers, such as health insurance companies, need to be more transparent in their data processing strategies **(PI6)** [24]. In the context of health insurances, further research about the use of personal health information from wearables or health application is needed **(SI3)**.

It might be interesting to consider the results in the context of the Prevention paradox by Geoffrey Rose **(SI4)**. In addition, further research might be about the consumers of healthy lifestyle technologies in relation to behavioral change of them due to self-tracking **(SI5)**. In respect of the sport sector, it is interesting to study the acceptance of immersive virtual reality technologies and their expected use **(SI6)**. Finally, additional research about gain or loss of health literacy through the quantification of the body, i.e. whether the user's confidence is either stronger in the body feeling or in the quantified values by technologies, would be needed **(SI7)**.

5   Conclusion and further research

Our contribution structures the adverse impacts of eHealth technologies, which can be used in a person's everyday life in order to improve health or health management in

the following eight areas: physical activity, nutrition, mindset, social aspect, addiction prevention, sleep, healthcare, and health literacy. With regard to continuous self-quantifying, social pressure can occur due to comparisons with other results. In case of not-achieving goals, users are dissatisfied and demotivated. Furthermore, trust in one's own body is neglected. Users focus more on their data and lose their internal awareness of body sensation. Thus, workouts or sleep may be perceived worse with evaluation of wearables than without. In the healthcare sector, data protection of wearables may not be the same as for medical devices. Acquiring health knowledge is no longer a priority, as the internet provides sufficient information. However, this complicates filtering the appropriate answers from the flood of online information. A poor understanding of health in combination with a weakly guided application may trigger stress.

With regard to our results and implications, our contribution provides new insights. We enrich the body of knowledge in the field of healthy lifestyle technologies creating six implications for healthcare providers, eHealth manufacturers or eHealth application developers. In addition, we derived seven ideas for further research from our findings.

In this contribution, limitations exist in the completeness, which is not given e.g. due to the limited number of databases searched. In addition, we conducted only short interviews with German participants. Moreover, this contribution did not focus on the perceived adverse impacts of the respondents and on the service provider, who plays a central role in to the context of healthy lifestyle technologies.

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