User types, psycho-social effects and societal trends related to the use of consumer health technologies

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Abstract

Objective: The term consumer health technologies we use in this paper refers to fitness and health apps, wearables and other self-tracking devices that collect health-related data. Our paper aims to bridge the gap between the growing literature base of sociological research and ethical reflection on the (non-intended) effects of consumer health technology use on the psycho-social level, such as stress, responsibilization or a loss of intuitive sense for signs of health or illness. Special consideration should be given to vulnerable individuals, as the positive and negative effects of consumer health technology use may be unequally distributed. This perspective may help to guide policymaking and the responsible development of consumer health technologies.

Methods: Using a narrative review approach, we refer to empirical and theoretical studies dealing with user types and effects related to the use of consumer health technologies. We provide an overview of consumer health technology user typologies and evidence of the unintended psycho-social effects of consumer health technology use. On this basis, we propose a user typology that may serve as a future tool for ethical reflection on negative side effects.

Results: Evidence of the potential negative side effects of consumer health technology use, as presented in the literature, is inconclusive due to the high diversity of consumer health technology users and the way they use consumer health technologies. Our proposed user typology aims to more comprehensively document the diversity of users by incorporating the way in which users identify with and use their self-tracked data, attitudes towards the new technology and social interactions via consumer health technologies, and the purpose and self-determinedness of consumer health technology use.

Conclusions: More systematic and quantitative empirical research on the effects of consumer health technology use in diverse settings and with diverse user types is necessary to inform public health policy. In addition to evidence-based certification of medical consumer health technologies, more practical and flexible ways to protect users from side effects may have to be developed and adopted, especially regarding the increasing number of non-medical consumer health technologies.

Keywords

Consumer Health Technologies, wearables, health apps, mobile health, ethics, responsible innovation, self-tracking, effectiveness, side-effects, social effects, psychological effects

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Introduction

Consumer health technologies (CHTs) such as wearables, fitness and health mobile apps and other devices, are commonly used by individuals in private settings to monitor daily activities, as well as numerous physical

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and psychological parameters that can be used, for instance, to monitor health issues. These CHTs are widely used worldwide according to market research institutes, e.g., in the US in 2021, 59% of the general population tracked steps, 42% athletic performance, and 37% heart health, and the global CHT market is expected to expand.[1] Global health crises like the coronavirus disease 2019 (COVID-19) pandemic may have even accelerated this trend,[2] as e.g., shown in Germany, where the number of users of health and fitness apps increased 16% within two months in 2020.[3] Common parameters which are tracked with CHTs include heart rate, step count, running pace, calories burned, food and drink intake, weight, stress level, sleep patterns and mood level.[4,5] Furthermore, the development of diverse sensor technologies, such as electroencephalogram,[6] spectroscopy,[7] or breathing sensors,[8] which can be incorporated in CHTs, increase the possibilities for personal monitoring. Despite the huge number of devices and apps on the free market and in app stores, the market for certified health apps available via health insurance companies (e.g., 12 health apps in Germany based on the Digital Health Care Act[9]) is a niche so far.

Although only a few CHTs have been tested for quality and their ability to deliver on their health and well-being claims, CHTs, in general, are surrounded by promises of benefits for healthcare systems and individuals: CHTs are supposed to foster better, more efficient healthcare, based on 'personalized healthcare' model of targeted, preventative and participatory healthcare,[10] and create fitter, happier, more productive individuals enabled through self-knowledge.[11] Moreover continuous and real-time monitoring of health parameters is seen as essential for better management of the rising number of patients with chronic diseases.[12] Self-tracking may also take place outside of the institutionalized healthcare system, e.g., in the quantified self-movement, and offer self-empowerment in addition to prevention or self-optimization.[13] However, data breaches,[14] insufficient regulation, ambiguous evidence[15] to back up claims regarding health improvements, and critical studies regarding the validity of data from CHTs are currently dampening expectations.[16] Regarding societal issues, critical commentators see the COVID-19 pandemic as enabling 'a public health intelligence revolution, where devices, apps and insights are promoted as essential, from the individual to the state level',[17] but point out the ambiguities with regard to surveillance, responsibilization and commercial use of data, which push CHTs use.[18,19] This critique is well-aligned with the focus of public discussion on data security and privacy issues.[20]

The potential negative side effects of CHT use at the psycho-social level, such as emotional distress, and a threatening decline of the solidarity principle in health care due to insurance bonus programmes of dubious economic value,[21] have been pointed out in some studies exploring social and ethical issues and public health.[22,23] However, in our view and according to other authors, these issues are less in the spotlight of public discussion and research.[2,24,26] Furthermore, such research on the ethical and societal aspects of CHTs refers to rather sparse empirical evidence and proposes to conceptualize such unintended effects more precisely and better document them.[23] Although systematic review articles of the growing amount of empirical research have been published, and systematize the research base according to themes on the user level, like motivations, reasons for continuance, and effects of CHT use,[27] they lack an ethical perspective. The question of interest here is how to engage users with CHTs for sustained periods of time, assuming this is a good indicator of (intended, positive) effectiveness,[27] but not whether there are non-intended, negative effects or who could be at risk of experiencing them.

Addressing this research gap, the primary objective of this narrative review is to assess the neglected negative side effects of CHT use and raise awareness of the potential vulnerabilities of CHT users. Another objective is to systematize those effects better and relate them to societal trends based on the (more) theoretical literature on self-tracking. For this purpose, we use a user typology not only as a tool to think about the ethical issues of CHT effects, especially regarding individual or group-related vulnerabilities,[2,26] but also as a starting point for investigating them more systematically. Such research is essential in order to find measures for the protection of CHTs users from unintended harm, and to counteract the widening of inequalities through digital health technologies.[15,26] Our focus on the negative psycho-social effects, which to date have been somewhat neglected (in both regulatory and ethical debates), does not mean that we are not aware of the potential positive effects of CHT use for health and wellbeing. We want to contribute to a nuanced view[28] on both the promising and the 'dark' side[25,29] of CHT use. What we will not provide here is a review of the primary intended positive effects of CHT use, which have been discussed in depth elsewhere for fitness trackers,[30] or of randomized controlled trials (RCTs) for specific health apps (for examples see the DIGA catalogue[9]).

The paper is structured as follows: Following a description of the methodology, in the first part of the results section we provide an overview of user typologies as proposed in the literature and describe them with regard to commonalities and differences. In the second part, we present empirical evidence for unintended side-effects on the psycho-social level. In the third part, we introduce the concept of vulnerabilities, and present empirical findings about the influence of demographics (specifically, socio-economic status) on CHTs use. *In the discussion,* we propose a new user typology based on reflections on the presented material.

Method

Aiming to gain an initial impression of the topic of CHT use and its facets, a literature review was conducted from February to April 2021, following a narrative review approach.[31,32] Narrative reviews are comprehensive narrative syntheses of previously published information,[33] where findings relating to a topic are put into a broader perspective.[34] The aim is to summarize what has been written on a particular topic by giving an overview of selected articles, rather than making generalizations based on what was reviewed.[33] Thus, it provides a comprehensive background for understanding current knowledge and highlighting the significance of new research.[35]

A preliminary search of the literature was conducted in electronic databases such as PubMed, Web of Science, Scopus and EBSCO, specifically Sportdiscus and the search engine Google Scholar, with a view to identifying already published work[36] in the following thematic areas related to CHT: user types, unintended side effects of use (including psycho-social effects) and societal trends. Only papers published in English or German were included in the analysis. No restricted timeline was imposed. Papers were excluded when there was no possibility to obtain the full text, or when after abstract screening there was no connection to the abovementioned thematic focus.

A narrative review is a more traditional form of literature review that has the advantages of flexibility and appropriateness to inductive research and qualitative research designs.[32] It permits a wider scope than systematic reviews, which are strategically focused.[32] The breadth of the search allows us to draw reasonable conclusions about the general direction of the research field and point out research gaps in terms of the number of studies available (e.g., that there is much more qualitative research with heterogenous and small samples than quantitative research on representative samples).

Results

In this first part of the results section, the ways of CHT use or CHT users are categorized and described (user typologies) in the literature are summarized. In the second part, we present empirical evidence for unintended side-effects on the social and psychological levels, and relate them to the different societal drivers identified in the literature. In the third part, we introduce the concept of vulnerabilities, and present empirical findings about the influence of socioeconomic status on CHT use.

User typologies

User types. Five user typologies were identified in the literature review, as presented and described in Table 1. Gerhard and Hepp[37] describe 'Enthusiasts' and 'Pragmatists' as two different types of CHT users. The former use CHTs in a more playful way, in communities rather than alone, and with no fixed goals. The latter use of CHTs rather in private settings, and have specific goals they want to achieve through self-tracking, e.g., a certain fitness level or prevention of a certain disease. Also, the range of CHTs used and the tracking parameters differ. Pragmatists have a rather limited tracking repertoire in comparison to Enthusiasts.

Maeyer and Markopolous differentiate 'Social', 'Achiever' and 'Avid self-trackers'.[38] The Social self-tracker likes to share their data within a group, for example on the platform of their device in order to attain reciprocal stimulation and motivation for achieving mutual goals. A connection to others is also important for the Achiever Self-tracker, who loves to compete and pursue self-set goals. The Avid Self-Tracker aims for self-awareness and a healthy lifestyle, and integrates self-tracking fully into their life; they like to analyse data, up to the point of creating a digital doppelganger or digital mirror through self-tracking.

Seshagiri et al. describe four types of CHT users.[40] The 'Competitive Beginner' starts fitness activities without a specific aim, is looking for a competitive environment and desires social confirmation. The 'Passive Practitioner' tries to include tracking with little effort in their daily life due to domestic and job-related responsibilities and thus prefers passive/automatic tracking, with focus on daily activity, such as step count. The 'Challenge Seeker', who is already physically active, is looking for a new way to improve and create a more varied exercise regime. The 'Active Reviver' has stopped being physically active and is looking for motivating feedback from CHTs and other physically active persons.

Kupfer[39] differentiates between short- and long-term users, which she associates with curiosity and pattern-seeking respectively, and also identifies data-sharing users who have social goals like peer comparison and self-representation. Two further user types aim to meet a specific (health/fitness) goal or identify a (health) problem.

All three typologies make a distinction between more goal-oriented and more self-sufficient CHT users, and identify the social aspect as one important factor in discerning user types; the fourth typology focuses on goal-oriented sportive CHT use, differentiating various degrees of ambition. Selke et al.[2], present a typology with a special focus on vulnerabilities with regard to self-tracking. The authors distinguish social and digital vulnerability, resulting in three vulnerable types (data vulnerable, socially and data vulnerable, and socially vulnerable) and one competent sovereign type (digital sovereignty) that uses CHTs self-determinedly.

Use practices and modes. The five studies presented above explicitly distinguish user 'types', but many other scholars differentiate ways of using CHTs or underlying

Table 1. User typologies and distinguishing characteristics (practices, motivations) of the user types as described by different authors.

Authors, year	User types	Characteristics (practices and motivations)
Gerhard & Hepp (2018)[37]	Enthusiast	Sharing data, control, lifestyle
	Pragmatist	Goal oriented, private, self-centred
Mayer & Markopoulos (2018)[38]	Social self-tracker	Community, goal oriented, mutual stimulation
	Achiever self-tracker	Goal oriented, competition, sharing data
	Avid self-tracker	Lifestyle, datafication, control
Kupfer (2016)[39]	Long-term users and pattern-seeking individuals	Compulsively recording a number of data streams with no end date
	Goal-pursuing individuals	Accomplishing a specific goal within a limited time frame
	Problem-solving individuals	Monitoring to identify a problem
	Short-term users	Curiosity
	Sharing individuals	Self-representation and peer comparison
Seshagiri et al. (2016)[40]	Competitive beginner	Competition, contemplation, confirmation in sports
	Active reviver	Re-entry, feedback, community in sports
	Challenge seeker	Alternation, challenge in sports
	Passive practitioner	Passive tracking, daily activities
Selke et al. (2021)[2]	Data vulnerable	Self-chosen dependency from data
	Socially and data vulnerable	Other-directed dependency from data
	Socially vulnerable	Excluded from consumer health technology (CHT) use
	Digital sovereign	Self-determined use according to own wishes

motivations. Heyen[41] explicitly argues that it is difficult to categorize self-trackers and that it might make more sense to typologize the ways CHTs are used (we refer to this aspect in the following as 'practices'), but other scholars do not reflect further on the rationale for the chosen subject/aspect of categorization. It is thus most often not clear whether the scholars consider the use practices and motivations they distinguish as combinable (e.g., Lupton[19] and Suh[42]) or rather mutually exclusive attributes, and whether individual users are in a fixed user practice state, or transition through different states (as described in Costa Figueiredo[43]). Table 2 summarizes the different practices and/or motivations for CHT use found in the literature review.

Motivations and aims which may be distinguished are fun/entertainment, and performance improvement,[4] hedonic,

utilitarian, and eudaemonic,[42] self-association, -design, -discipline, and -healing,[47] expertization[5] and empowerment.[52] As more uncommon motivations or aims, some athletes use fitness apps as a means to pursue their 'biographical project' and (self-)identify as a (professional) athlete,[46,53] or to reach 'digital immortality'.[44]

Heyen describes four stages of increasing active engagement and research character: for fun/without concrete aims, monitoring and optimization, as research project and development of own apps/measurement tools for tracking.[41] Some other studies differentiate use practices with regard to active engagement (or lack of it), and inner and external drivers for tracking, such as active/passive,[4,45] and physician initiated/self-initiated. Costa Figueiredo et al. distinguish five types of engagement with data in the special case of fertility tracking, which

Table 2. Main characteristics or associated concepts of the different practices of/motivations for consumer health technology (CHT) use, according to different authors.

Authors, year	Practices/motivations	Characteristics
Heyen (2016)	Without concrete aims	No personal aim
	Monitoring and optimization	Surveillance, goal oriented, optimisation
	Research project	Datafication, research, citizen science, knowledge
	Research & development	(app-)Development, citizen science
Selke (2016)[44]	Health monitoring	Prevention or disease management
	Digital immortality	Outsourced memory
Bode & Kristensen (2018)[45]; Duttweiler & Passoth (2016)[4]	Active tracking	With user input
	Passive tracking	Without user input
Duttweiler (2016)[46]	Fun	Without aim, for entertainment
	Performance improvement	Optimisation
	Biographical project/sports professionalism	Integral part of identity
Selke et al. (2021)[2]	Self-determined/voluntary	Independence from external pressure or personal necessity
	Other-directed/involuntary	Arising from institutional power or due to a disease
Gimpel et al. (2013)[47]	Physician-initiated	Invitation or order to track by physician
	Self-initiated	Self-responsible self-tracking
Pols et al. (2019)[48]	Semiotic-aesthetic style	Oriented towards discovering patterns in behaviour or bodily signs
	Objectivist-changer style	Oriented towards changing behaviour based on objective measurements
Milward et al. (2018)[49]	Trackers	Monitor and understand quantified self-data
	Cut-downers	Goal of reducing alcohol consumption
	Non-committers	Initially enthusiastic, but no benefit gained
Suh (2018)[42]	Hedonic	Based on enjoyment, e.g., of aesthetic visuals
	Eudaemonic	Seeking meaning, identity development, self-growth, and pursuit of excellence
	Utilitarian	Based on goal-setting, focus on usefulness and functionality
Yli-Kauhaluoma & Pantzar (2018)[50]	Unexperienced	Confusion and doubts common due to problems with data interpretation

Table 2. Continued.

Authors, year	Practices/motivations	Characteristics
	Experienced	Confusion and doubts common due to problems with data accuracy and interpretation
	Extreme	Confusion and doubts common due to problems with data accuracy
Costa Figueiredo et al. (2018)[43]	Positive	Excited, hopeful, learning to understand data
	Burdened	Stressed, increase in tracking
	Obsessed	Trust in data, measures take over feelings
	Trapped	Guilt and dependence
Lupton (2014, 2016)[19,51]	Private	Private, optimization, self-awareness, self-knowledge
	Pushed	Incentive by a third party
	Communal	Community, sharing, citizen science
	Imposed	Forced by a third party
	Exploited	Misuse and exploitation of collected data

includes both an action and an emotional component: positive, burdened, obsessive, trapped and abandoning.[43] This typology is especially interesting with regard to our objectives, as it points out negative side-effects, like guilt, stress and dependence. Of similar relevance is that of Lupton, which focuses on the (external) driving forces for CHT use and differentiates between private, pushed, communal, imposed, or exploited self-tracking, referring to the economic interests and drivers of self-tracking. In private self-tracking the collected data is not shared and is used to improve and optimize awareness and health. Pushed self-tracking is driven by a third party, e. g., an employer or insurance companies. Communal self-tracking focuses on being part of a community through sharing and comparing personal data via social media and other platforms. Imposed self-tracking describes a practice where individuals are required to use self-tracking solely for the benefit of others. Exploited self-tracking describes the use of personal data by others for their (commercial) benefit, for instance, market research.[19] Regarding these practices, Lupton highlights their intersection. Private self-tracking may be combined with communal self-tracking and there are blurred lines between imposed and pushed self-tracking. The typologies of Pols et al.[48] and Milward et al.[49] describe the difference between tracking to gain understanding and awareness and tracking to reach a certain goal (e.g., reduce alcohol consumption).

Rather than deducing types of users from qualitative or quantitative data, Yli-Kauhaluoma & Pantzar[50] pre-defined user categories according to regularity and intensity of CHT use (inexperienced, experienced, or extreme self-trackers), and described differences with regard to their problems with data accuracy and interpretation.[50]

Personas. All these typologies and differentiations of use practices pick out either one single aspect of CHT use to describe (e.g., kind of motivation, or engagement), or several, e.g., Selke data handling and goals with regard to health, and thus more or less reduce complexity. Meidert et al. and Herzog et al. describe different user types in the form of fictional characters – the personas – based on real data and observations (see Table 3). The descriptions of the personas include factual descriptions such as profession, age, gender and family status, but also aims, motivations, concerns, skills, knowledge, practices, and negative and positive effects of CHT use in a story-like format. They try to generalize, but also retain a great amount of real-world complexity of CHT use and users.

Societal trends as framings for unintended effects of CHT use

Tracking health parameters has a long history, e.g., an insurance company calculated 'healthy' norm values for body weight already in the 1860s, and in the 1970s self-tracking of blood pressure gained popularity, as a means to prevent disease but also to gain autonomy from health

Table 3. Characteristics and unintended negative (-) and positive (+) consumer health technologies (CHT) use effects on examples of personas, as proposed by different authors.

Authors	Personas	Description
Herzog et al.[26]	Alex, well-paid consultant	(+) Motivation to do sports through social competition (-) addiction, neglect of other activities
	Nadine, single mother, underpaid and obese	(+) Potentially saving time and money compared with sports group and healthy food - emotional distress, embarrassment
	Anna, the sportive student	(+) More effective training, feeling for heart frequency, motivation through comparison with others (-) Concerns about addiction and social pressure, dependence and overtraining, location data security
Meidert et al.[5]	Toby, the technophile informatician	(+) Gain of knowledge, fun, exchange with others about pros and cons of different CHTs (-) techno-optimism may lead to neglecting alternative health promoting options, frustration due to missed goals and opacity of data use
	Tamara, student with chronic disease	(+) Control and freedom through easy measurement of blood glucose (-) compulsive repetition of measurements, loss of feeling for bodily signs

professionals.[46] The scale and pervasiveness of CHT use are however seen as a new socio-technical arrangement,[46] provoking questions about the drivers of this development. Three societal drivers of CHT use which are often discussed are *Economization and self-optimization*, *Datafication*, and *Individualization*.

While the positive effects of CHT use are often framed as a result of technological design options and functionality/usability (e.g., how do gamification elements motivate users most effectively[25]), negative side effects are often portrayed as a consequence of the societal climate in which CHTs are used. For the purposes of this narrative review, we wish to present this perspective in order to structure our findings relating to the negative psycho-social side effects. In our discussion, however, we will then attempt to arrive at a more user-centered way of looking at negative side-effects, without neglecting the societal embeddedness of CHTs and their users. To this end, we will use the concept of user types and draw on the existing user typologies we presented above.

Economization of health care and self-optimization

Economic aspects are seen as a major driver of CHT use, as there is a large and growing market for CHTs and the data generated by them,[15,54] and CHTs are seen as a solution for health care systems struggling with limited resources.[55] On the individual level, self-optimization can be seen as a form of economization in neoliberal societies as well.[4,5,51]

Besides better health (or self-optimization related e.g., to fitness, beauty or work performance), the biggest promise of CHT use as an outcome is expertization and empowerment.[41,52,56] The underlying hope is to lead to more efficient and happier lives without being dependent on expert knowledge, which is doubted to give credit to the individuality of one's own body.[46] Self-expertization is meant in the sense that it is not restricted to passively gaining general knowledge about medical science, but actively producing self-knowledge, and thus doing 'personal science'.[41,57] Rising health care costs are assumed to be an important inspiration for dissemination of these promises, not only by CHT manufacturers, but also states and insurers, and a neoliberal shift of responsibility to the individual is discussed critically.[19,58,60] Lupton describes pushed, imposed or exploited tracking modes, suggesting potential negative effects on CHT users arising from the economic interests of other stakeholders.

Empirical research suggests that data collection and sharing is sometimes experienced as unpaid patient work for industry,[61] while at the same time proposed as being for the common good.[59] Furthermore, CHT use may constantly remind the user of having a disease,[61] lead to feelings of guilt, stress or failure, and obsessive self-optimizing behaviour, e.g., in the context of nutrition apps and eating disorders or mood trackers.[43,62,64] In a study with patients with chronic obstructive pulmonary disease, users of a step counter felt stressful pressure to exercise, and had bad feelings about 'losing steps' when not wearing their device.[65] Toner suggests developing ways of using CHTs in a manner that counteracts the interests of other stakeholders, and repurposes CHTs for one's own true benefit,[29] while Vesnic-Alujevic et al. even suggest developing CHTs on one's own.[58] Quantified self (QS) is a movement depicted as proactively counteracting the dominant data collection practices of powerful institutions and corporations,[66] pronouncing e.g., self-ownership

and independent management of data (e.g., Open Humans[67]). However, it is unclear which groups of CHT users and how many of them see themselves as citizen- or patient-scientists or members of the QS community, and for how many of them the promise of self-expertization and empowerment is being fulfilled. Research indicates that there is even a gap between aspiration and reality within the QS community[2] (p. 39). There is evidence that especially in certain groups, societal pressure to optimise may lead to negative effects. e.g., exercise dependency is exacerbated by CHT use in female users,[68] who are supposed to be influenced by specifically gendered expectations (weight loss and self-discipline for the purposes of beauty).[69] Without sufficient guidance in economized health care systems, especially on the quality criteria of non-certified apps,[15] there is a risk that false diagnoses may result in fear,[70,71] though we found no empirical studies that report on this issue.

Datafication: Digitalization in health care and quantification of health experience

Datafication is a prerequisite for self-tracking with CHTs, which mostly work with quantitative data measured via sensors. Datafication promises more exact knowledge about body functions through continuous monitoring and comparisons with others or norm values over time (knowledge through numbers[72]). It may also provide users with positive feelings of control,[73] much sought-after in insecure times, and to an unburdening of responsibility, e.g., in the case of COVID-19 tracking apps[2] (p. 16/70). Many CHT users are, however, not very responsive to 'naked numbers', but are attracted by aesthetics like visualizations of data[2(p 36)], and may personally contextualize data to give meaning to it.[48] Whatever form measurements and their representations take, a sociology of quantification assumes that there is a reciprocal, reactive relationship between data and social life.[74]

One big risk and negative social effect seen in datafication is that it can lead to a reductionist view of medicine and a devaluation or neglect of the human experience and subjective feelings.[2,29] In the case of diabetes, control of glucose levels is enabled through continuous monitoring and calculation, using many different individual variables.[48] This may lead to a form of control obsession and cognitive overload, but may also help users acquire a better sense of the correlation between their behaviour and the blood glucose values.[75]

The concern that CHT use can lead to a loss of personality aspects relevant to identity, and a stressful feeling of being controlled by numbers, has been reported in a study with elderly people.[76] Especially when CHTs become an integral part of users' physical self-understanding, it may lead to stress when recommended standards of physical activity are not met, and a feeling of dependency.[65] Professional athletes, on the contrary, saw the practice of CHT use as an important and accepted part of their identity.[53] Datafication may help some people in finding a 'stable identity in a liquid world', raising questions about the extent of dependence CHT use may generate.[77]

CHT use may also lead to negative emotions and self-perceptions, such as hatred, and self-distrust, and hinder enjoyment of exercise and the environment.[46,73] Confusion and doubt arise when there is a mismatch between data and experiences Klicken oder tippen Sie hier, um Text einzugeben.[50] In the especially emotionally loaded case of fertility tracking, transitioning through different stages of emotions about data, from excited, to stressed and frustrated, to obsessed, has been observed.[43] Chronic heart patients may relate fitness tracker data directly to their disease, with the result that they may experience anything from insight to doubt, and from reassurement to anxiety.[78]

CHTs may be designed as too reductionistic with regard to their concept of health or disease, as, e.g., judged for the case of endometriosis.[79] However, CHT use may also lead to an increased repertoire of self-awareness, which Pols et al. describe as the 'aesthetic-semiotic style' of self-tracking, and thus enable a more holistic understanding of one's health and well-being.[48] CHT use may also create awareness about problematic behaviours and health problems.[73,80] Ethnographic studies have shown that CHT use can be a practice of positively valued mindfulness and communicative/narrative aid, i.e., the exact opposite of 'data fetishism'.[81] Independent of the question whether datafication via CHTs has positive or negative effects in terms of meaning for users' self-valuation, feelings and knowledge, a risk is that if aims are not reflected carefully and a certain distance is taken from the data, 'good' data can become an end in itself, and result in a form of psychological dependency.[82]

Individualization through personalized CHT technology and online communities

CHTs often claim to give personalized recommendations, such as individualized training or nutritional guidance.[83] The wish for individualized CHTs is also stated by many users in various studies, especially if the usage is connected with disease management or multiple chronic conditions.[84,86] CHT use as a practice can be both highly individualized, using a DIY (do-it-yourself) device,[87] and/or designing personal research projects in QS communities like Open Humans,[67] or rather 'standardised' with regard to the CHTs used, data collected, and methods to interpret data (e.g., tracking step count).

Independent from this aspect of individuality with regard to CHT users' technology choices and their related goals,

CHT use can be practised more or less communally. This aspect is reflected in several of the typologies we found.[37,39] Communal CHT use takes place in interaction with a community, such as a device manufacturer's forum, or a quantified self-group or friends with whom data is shared for comparison and learning. The relevance and meaning of one's own data is discussed, and motivation for CHT use is sought in online communities.[58] The use of online communities was found to lead to significantly greater engagement in physical activity in a cross-sectional study.[88] One explanation for this motivational effect of the community aspect is related to individualization, as for some users exchanging and comparing data is an important means to build up individuality: social identity, a concept closely related to individualization, is defined by social relationships, and is also formed by comparison with others, e.g., through self-tracking.[89] Social media in general have been a driver of individualization and its strongest form, self-optimization, especially in generation Y, who grew up with the internet.[89] Developers and marketers of CHTs attempt to create an 'affective atmosphere' of community in users.[90] Referring to a claim by Lupton,[91] Ajana[92] writes that data sharing in the context of CHT use 'appeals to a deeply felt desire (…) to create social bonds and a sense of belonging'.

While we found no research specifically looking at the psycho-social implications of CHT diversification and choice as such, one may assume that there are differences in access to this means for individualization for financial and social reasons. There may be social or patient groups with fewer opportunities to compare with others due to time constraints or digital literacy limitations, or less options to choose between CHTs, e.g., persons with paraplegia or amputations,[2] or rare diseases. The same may be true for access to communities. Senabre Hidalgo et al.[93] studied the research ethos and social aspects of communality within a QS community, showing that learning from others and in turn sharing knowledge gained by CHT use is common. Whether these specialized QS communities are truly 'solidaristic' or rather exclusive has however been questioned.[94]

Besides this access issue with its implications for health equity, the communality aspect as such bears risks. Gamification as a design element of CHTs and social media networks may have a synergistic effect for motivating users.[95] But social media and gamification mechanisms may also have a downside due to addiction risks and social pressure.[96] Comparing performance with others via social media may have demotivating effects with regard to engagement in health-related behaviours,[97] and be counterproductive also in mental health apps.[89] In a study with juvenile girls, the users felt that CHTs as such reduce the social element of sports,[98] which might be another counteracting demotivational factor. Another general pitfall of motivation for sports by technological means is that a motivational dependency effect on the CHT was observed, which was stronger for participants with low intrinsic motivation for physical activity.[82]

Vulnerabilities and ethical issues of CHT use

Vulnerability is understood as an increased risk of harm[2(p 76)], arising from a combination of individual mental and physical constitution, environmental factors and social context[2] (p.111). Herzog et al. propose an expansion of the traditional understanding of vulnerability in medical ethics, which is focused on the individual and the ability to give informed consent, to include also vulnerability on a societal level and other individual dimensions, e.g., psycho-social dimensions.[26] This broader understanding allows identification of the 'vulnerabilizing' factors located in societal structures, like unequal socio-economic position, and thus also the ethical dimension of CHT vulnerabilities from a (social) justice perspective.[26] The question of which individual users or user types are most at risk of experiencing negative side-effects can also be formulated as a question about vulnerabilizing factors.

Socio-economic status is one such exemplary factor,[26] and there is some knowledge regarding its relation to (non-)use of CHTs (see Grundy 2022 and references therein for details).[15] Not everyone may have the time and financial resources to invest in CHTs and their use, or even engage with (online) communities like Quantified Self.[54] It is widely acknowledged that health inequalities are linked to socio-economic status and that digital technology in health may exacerbate these inequalities, either due to differences in digital literacy, use of these technologies, or access to technology.[23,99] Numerous studies have shown that individuals with a higher socio-economic status, i.e., income and education, and better health, use CHTs more often.[38,61,100,105] This finding may be explained with the existence of personal resources like digital literacy and ownership of high-quality CHTs, and the motivation to lead a healthy lifestyle in higher socio-economic groups.[100]

Discussion

We will now shortly summarize our overview of the existing CHT user typologies, and then discuss aspects of CHT use for a side-effect-sensitive typology. We will then discuss the implications of psycho-social negative effects with regard to vulnerabilities in more depth.

Existing CHT user typologies

Taken together, most user typologies in the literature are based on the motivations or practices of users. Few of them point to external driving forces for individual CHT use, negative effects, or vulnerabilities of individual users. The level of abstraction/differentiation of types differs

considerably between typologies and persona descriptions. The purpose for which they are proposed also differs. Some typologies are tailored to/deduced from a very specific user group, while others have the aspiration to capture a broader user population. More abstract typologies may help to draw attention to one specific aspect of CHT use, e.g., sportive ambitions, or the importance of social elements. The persona typology helps us to think about social and ethical consequences for specific groups of people.[26] Both may summarize empirically identified user groups,[5] which may be helpful for technology development and evaluation.

Aspects of CHT use for a side-effect-sensitive typology

What is missing is a typology aimed at documenting all important aspects that may influence the risk of side effects of CHT use. In the following, we propose such a typology based on reflections on our two results sections. An overview of negative side effects is given in Table 4, and we will explain the related typology dimensions/aspects in the following sections.

First, we will consider the concept of vulnerabilities and how our user typology may help to reflect on them.

Vulnerabilities and CHT use

Selke et al.[2(p 68)] describe a typology of CHT users based on data and social vulnerability. The first is defined as a digital dependency and/or acceptance of a loss of data protection, while social vulnerability may be either an exclusion from CHT use (due to, e.g., disability or economic factors), or an externally pushed or controlled CHT use, e.g., in the

work place.[2] Selke et al. thus make a link between potential negative effects in general (risk of harm) of CHT use, and personal and societal factors, through a user typology based on the concept of vulnerability. While we will base our typology on aspects of the societal drivers we identified, we also include the concept of vulnerability in our typology, and want to point out potential 'vulnerabilizing' factors for each type.

Besides identifying risks for known vulnerable/discriminated groups, Herzog, Wild and Kellmeyer[26] point out that CHTs pose the risk of creating vulnerabilities in individuals who normally would not fall under the category of 'vulnerable', such as healthy and wealthy individuals who become addicted to CHT use due to psychological predispositions and social context. Further 'vulnerabilizing' factors may be gender, social context, disease, economic situation, knowledge/education, and psychological predispositions. Further research is needed to explore whether these factors could lead to an increased risk of non-voluntary use, non-use, or negative side-effects of CHTs.

Current research suggests that certain disadvantaged demographics use CHTs less, which leads to a widening of inequalities.[15] However, not so much is known in detail about why certain demographics do not use CHTs for sustained time frames. There may be financial barriers, digital literacy may play a role, or apps may not be designed with disadvantaged groups in mind, targeting instead the wealthy and healthy.[15] This may also imply that disadvantaged groups try out CHTs but then experience negative effects that make them stop using them again. Alternatively, they may use CHTs despite the negative side effects (of which they may or may not be aware). For now, one can only speculate about the diverse factors of vulnerability apart from socio-economic status, as we

Table 4. Overview of negative psycho-social side effects and their societal frames, and the typology aspects chosen and deduced from the typologies overview.

Societal Trend/Driver of CHT use	Datafication	Economisation	Individualisation
Related psycho-social negative side-effects	• Hindering enjoyment of exercise and environment [29,46,73] • dependence [43,65,77,82] • feeling of being controlled by numbers [76] • loss of intuitive body knowledge [29] • frustration due to mismatch of data and experience [43,50] • anxiety and doubt [85]	• Reminder of disease [61] • patient work [61] • stress and negative self-appraisal/guilt/feeling of failure [43,62,65] • fears due to false self-diagnoses [70,71] • • obsessive behaviour, exercise dependency [68]	• Motivational dependency and externalisation of motivation [82] • diminishing „real 'social interactions [98] • demotivating effect of competition [97] • counter-productive comparisons in the case of mental health [89] • social pressure [96] • risk of addiction/ excessive exercise[96]
Typology dimensions/ aspects	Distanced or identifying holistic or reductionistic	Self- or other-determined health-oriented or optimizing	High or low level of social interaction individualized or mass technology

are doing in the discussion now. Reflecting vulnerabilities may also take the form of writing down the dimensions/aspects of the typology we propose and thinking about potential risks in interaction with personal factors (like we did for two aspects in Figure 1). We will describe the content of this Figure in detail in the following section.

- Individualization and the related level of social interaction and individualization of technology

Current research suggests that there is a complex interplay of individualization and social interactions via CHTs with the motivation to use CHTs and some potential side effects. There is evidence of (motivational) dependency on CHTs and negative emotional effects of social comparisons (as summarized in Table 4). Two key aspects of a typology of users are, thus, individualized technology and social interaction via CHTs. Future sociological and empirical ethics research could e.g., investigate the psycho-social effects of comparisons with standard values, especially for individuals in special circumstances, like wearing limb prostheses (see upper-right square in Figure 1). Responsible developers of CHTs should take account of individuals with special needs but limited financial resources, who cannot benefit much from common affordable mass technology (see right-down square in Figure 1). (Algorithm-based) individualization of technology and social interaction, although highly valued by users and a

motivating factor, may bear a risk for patients with a lack of health literacy and tech enthusiasm (see upper-left square in Figure 1). Complex individualized technology may also be a risk for users when used without any guidance (which may, but does not have to come from a user community).

- Economization – aims and self-determinedness of CHT use

The evidence for feelings of failure or guilt with regard to CHT use can be interpreted as responsibilization in a context of economization of healthcare systems and the trend towards self-optimization, which are often described as key drivers for CHT use. There are two key defining characteristics of CHT use which are discussed with regard to the societal context of economization, and which are also evident in some user typologies.[2,19] These are self- vs. other-determinedness, and health-oriented (with the aim to heal, monitor or diagnose) vs. optimizing (without a specific end, oriented towards fitness or beauty ideals).

While this typology does not offer a nuanced differentiation between levels of external (societal) pressure, like the one Lupton proposes,[19] the second dimension we add draws attention to the intersection of two aspects of CHT use. A hypothesis that could serve as a starting point for further research is, that the different types may be at more or less risk of experiencing the related psycho-social side-effects. For example, users pushed by social norms to self-optimize may develop a habit to negatively appraise themselves, based on data that shows they did not reach externally defined goals like a certain step count. Financial pressure may also lead to other-determinedness of CHT use, like in insurance bonus programmes, or in cases where CHTs are used as a substitute when there is a scarcity of physicians. While other-determinedness has, not without reason, a clear negative connotation, it may be neither a sufficient nor a necessary condition for risks. Certain personal characteristics of users may interact with CHT use aspects and create vulnerabilities. For example, false expectations about the capabilities of CHTs may lead to fear due to false diagnoses in not-so-digitally literate patients, although or even because they use CHTs in a self-determined manner (without guidance from professionals).

- Datafication and the related epistemic and emotional attitude towards self-tracked data

High level of social interaction - highly individualised CHTs	High level social interaction - mass technology
D and K vulnerability: seeking independence from the health care system by using sophisticated technology and learning in communities bears risks when you have a disease and overrate the potential of CHTs	**D and PE vulnerability:** comparisons frustrate those who rank below the „normal", which is especially harmful for individuals with existing psychological problems or who seek social recognition and identity through CHT use
K and SC vulnerability: without training how to use individualised/sophisticated CHTs, e.g. without medical personnel introducing the function of medical apps and no community to seek advice, there is a risk to experiencing more harm than good	**D, E and K vulnerability:** individuals with special needs, who cannot afford expensive CHTs, and/or no access to DIY/QS-communities may be unwillingly excluded from the other use types which have overall advantages with regard to motivation and usefulness of CHTs
Low level social interaction - highly individualised CHTs	Low level social interaction - mass CHTs

Figure 1. User types related to the societal trend of individualization, with examples of vulnerabilities potentially leading to a higher risk for negative effects and/or non-voluntary use of CHTs: Abbreviations for the vulnerabilities: D, SC, E, PE, K. D: disease; SC: social context; E: economic; PE: psychological/emotional; K: knowledge/digital literacy.

Taken together, the described empirical studies in our literature sample show a nuanced picture with regard to CHT users' feelings *towards* and personal meanings *of* their data and the effect datafication has on their subjective experiences and understanding of health. A polarized perspective on datafication as creating control and knowledge

at the cost of, or at least risking, a de-valuation of subjective experience is not realistic. People may self-identify more or less with their CHT data, which can have both negative and positive implications. From a more 'rational' or distanced perspective on data, datafication is simply a means to objectively validate hypotheses about the body and change behaviour.[48,52] From a more 'emotional' perspective, when users identify to a great extent with their data, this may have implications for CHT users' self-valuation and feelings while doing physical exercise, or even their capabilities to sense bodily aspects. While some users evaluate a reductionist approach (e.g., of self-tracking apps for endometriosis[79]) negatively, others may welcome reduced complexity, e.g., the generalized recommendation to take 10,000 steps every day to stay healthy.

Based on this complex picture, we propose two aspects based on the affective and personal relation to one's own data (distanced-rational vs. identifying-emotional) and the relevance of data vs. subjective experience for understanding of health (reductionist vs. holistic). The emotional-reductionist type and the emotional-holistic type lack an emotional distance from their data, but differ in how significant they deem the data as health or fitness indicators. The other two types are the rational-reductionist and the rational-holistic types, who both detach from their data, but differ in how significant they find the data, or rather trust their subjective experience. One may also describe that difference in terms of whether data is rather used instrumentally, to reach a specific goal like step count per day, or rather to gain better understanding and awareness.

These user types bear some resemblance to those described by Costa Figueiredo et al. and Yli-Kauhaluoma and Pantzar, as well as Pols et al. and Milward et al. due to their focus on emotions towards data and the relation of experience and data. However, the combination with the aspect of the understanding of health is new and may provide a fruitful new perspective on user types and risks. For example, one could speculate that persons with a very rational attitude and holistic understanding of health may not be attracted by the promise of datafication, or at the least might be irritated by far-reaching claims and interpretations of data, and consequently could be reluctant to use CHTs. Persons open to a reductionist understanding of health combined with an emotional relationship with their data might be enabled to feel in control by tracking certain data, but also at higher risk of distress or addiction. Psychological aspects, like how anxious a person is in general when it comes to health, or any state of emotional insecurity, could obviously play a big role with regard to these risks, and has to be taken into account as a vulnerabilizing factor. Health literacy and digital literacy are further personal aspects that may influence evaluations of the meaning and quality of data.

Conclusions

Practical use of the user typology

CHT use and its effects have to be understood as a complex socio-technical system in which the context, societal trends, technology, and the user interact, and the (medical, social, psychological, well-being) outcome is a result of this interaction. Societal trends like data commercialization or health care economization are often taken as the backdrop to critical accounts of CHT use. Furthermore, the technological design and functionality perspective is often used to research CHT user engagement, as a proxy for effectiveness. By contrast, the individual characteristics of users themselves are rarely the focus of CHT effect research. If anything, the correlation between demographic characteristics or socio-economic background and non-use is studied.

CHT typologies are different in that they focus on the users and their diverse use practices. However, most existing CHT user typologies are related to motivations for and practices of CHT use, but do not draw a line distinguishing these from likely outcome differences for the user types. This limits their usefulness when it comes to reflecting on policy and ethics. There is limited but not negligible evidence of the potential negative side effects of CHT use on a psycho-social level. The aim of our suggested typology is thus to document aspects of CHT technology, use and users which are more relatable to these effects. This is based on how users identify with and use their self-tracked data, their attitude toward new technology and social interactions via CHTs, as well as the purpose and self-determinedness of CHT use.

The typology we propose is relatively generic, but may also be a starting point for thinking about typologies for certain specific (groups of) CHTs. As an example, we found and described in the results a typology of users of an alcohol consumption reduction app.[49] The authors concluded that future app versions could be tailored to the different types of users. However, they used essentially one dimension of our typology (aim-oriented vs. tracking/awareness-raising), and the third type is the (initially enthusiastic) non-user. The question we would raise is what makes the non-users stop using the CHT after a short time (and consequently, not benefit from it). One hypothesis could be that it might be related to other typology dimensions we propose, and the related negative effects CHT use might have.

Future research

Regarding future research, our typology may thus serve as a starting point for more systematic sociological and empirical ethics research on CHT use. This entails some challenges, however. The aspects of CHT use which define the user types would have to be objectively measured in qualitative

and quantitative studies in order to establish more than anecdotal empirical evidence of the existence and incidence of different user types, and the correlations with negative effects. For example, the correlation between the psychological characteristics of users and their risk of addiction and overuse may be elucidated in quantitative studies. So far, there have been few attempts to measure the attitudes and characteristics of users with psychometric scales, like that of Kupfer.[39] An even more detailed real-world assessment of the negative consequences of CHT use in correlation with vulnerability factors (such as socio-demographic characteristics, gender, age, health status, education, psychological predisposition) would also allow specific support and countermeasures to be developed in terms of CHT design or education and support. CHT developers may add self-reflection tools for vulnerable user groups, counteracting e.g., the risks of adhering to stressful or even health-endangering excessive weight-loss behaviours.

Policy implications

RCTs are already mandatory in Germany for health apps to obtain formal certification (as DIGA) and be reimbursed. To date, these studies have often lacked control of the multitude of contextual factors which may affect CHT effects.[23] It is a challenge to evaluate the effectiveness of medical products in general, as these are often more complex than pharmaceuticals and require real-world evidence.[106] Regulation, user guidance approaches, and standards[107] are more technology-centered and do not take into account the vast diversity of users in terms of demographics and their way of using CHTs in real-life settings. There is a tendency to focus on the clinical area and assume a controlled setting when the safety of CHTs is being discussed.[108,109] Side effects in real-world settings may be neglected with this approach. More knowledge about the diversity of users may thus be key to generate robust evidence of the quality and effectiveness of CHTs and enable regulation downstream.

A more direct and upstream approach to mitigating potential negative effects could be participative development of CHTs, involving diverse user types and including minority and disadvantaged groups.[15,110] To give just two very compelling examples, fitness apps may be developed for people with paraplegia, as they are excluded by current fitness apps both in terms of the exercises they propose and the quantitative activity goals they predefine.[111] In a participatory study with male workers, the design and functionality requirements for mental health apps were studied in order to find ways to engage this group of people that very often see mental disorders as a stigma.[112]

Concerted efforts by researchers, regulators and developers of CHTs will be necessary to achieve a widespread understanding of quality issues and to raise awareness about the potentially ambiguous effects of these devices. Ultimately, the aim should be to enable every user to make informed choices about personally beneficial CHT, or about whether to reject CHT.

Limitations

By selecting an explorative narrative literature review as the methodology, the authors are aware that, due to the non-systematic literature review, some studies focusing on the negative (and positive) psycho-social effects of CHTs may not have been included in our review. Furthermore, our discussion includes an element of speculation regarding the correlation between demographics and personal factors of CHTs users, user types, and negative side-effects/risks. Our study should therefore be considered as a point of departure for future, more systematic quantitative and qualitative research and empirically grounded ethics.

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