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Promoting inequality? Self-monitoring applications and the problem of social justice

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Abstract
When it comes to improving the health of the general population, mHealth technologies with self-monitoring and intervention components hold a lot of promise. We argue, however, that due to various factors such as access, targeting, personal resources or incentives, self-monitoring applications run the risk of increasing health inequalities, thereby creating a problem of social justice. We review empirical evidence for "intervention-generated" inequalities, present arguments that self-monitoring applications are still morally acceptable, and develop approaches to avoid the promotion of health inequalities through self-monitoring applications.

Keywords Health inequality · Social inequality · Social justice · Health-monitoring · Self-monitoring · mHealth · Persuasive technology · Nudging · Health literacy · Health interventions · Intervention-generated inequalities

1 Introduction

The problem with social disadvantages is that they tend to *cluster* (Wolff and De-Shalit 2007): poverty leads to bad education; bad education leads to hard work under insecure conditions; hard work leads to lower quality of life. One of the strongest correlations of this sort is the one between people's social situation and their health. In many countries, women and men with low socio-economic status (SES) have a lower life expectancy than people with higher SES (Robert Koch-Institut 2015). This has not always been the case: up until the middle of the nineteenth century, there were hardly any differences in life expectancy among the general population, including the well-off (Deaton 2013). This suggests that current high levels of inequality are due to social and political conditions, rather than natural conditions such as geography or climate. To make things worse, those most in need of benefiting from preventive interventions are least likely to receive them (Lorenc et al. 2013). These socio-economic inequalities in health are a major challenge for health policy makers (Mackenbach and Kunst 1997). Therefore, a primary goal of prevention should be the improvement of equity in health; i.e., that all people are given the same chance to live a healthy life, regardless of income, education and professional status (Mielck 2002).

Mobile self-monitoring applications are seen as bearing great potential for the prevention of lifestyle-induced diseases by various stakeholders from politics and business as well as by users both nationally (Albrecht 2016) and internationally (Burke et al. 2015). Through personal self-monitoring, it is possible to review one's lifestyle, bodily functions and health development by means of data gathering and analysis and thus to control and to motivate a healthier lifestyle (McManus et al. 2018). This trend has received a lot of recent attention, and will likely continue to do so (Bundesministerium der Justiz und für Verbraucherschutz 2016; Burke et al. 2015; Kostkova 2015). Such persuasive technologies—hereafter referred to as self-monitoring

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applications—aim to improve or maintain people's welfare and health quickly, easily, at a low cost, and with few obvious drawbacks (Becker et al. 2014; Chatterjee and Price 2009). Self-monitoring technology and mobile tracking-devices that rely on sophisticated mechanisms of technological persuasion represent a forward-looking step in promoting healthier behavior. Interactive computer systems designed to change behavior or attitudes of their users are referred to as persuasive technologies (Fogg 2003, 2009). These technologies make recommendations or suggestions for how people can engage in healthy behavior. We are following the definition of Fogg and see persuasive technologies as interactive computer systems designed to change the health behavior and attitudes of their users. Embedded in a personalized health-monitoring system, with self-tracking and analyzing components, persuasion can help people to improve or maintain a healthy lifestyle. Via many widely used devices such as smartphones or smartwatches persuasive technologies enable better health decision making, encourage positive health behavior and empower users to take charge of their own health (Kostkova 2015). Lifestyle-based interventions such as motivational goal setting, action planning or self-monitoring are becoming more feasible for individuals due to personalized mobile technologies (Orrell and Brayne 2015). Recent reviews suggest that self-monitoring-applications have great potential to aid and modify people's lifestyle (Burke et al. 2015) and to encourage self-management in chronic conditions and patient autonomy (Boulos et al. 2011; Landry 2015; McManan et al. 2018).

However, lifestyle-based interventions, in general, have a potential downside with regards to promoting inequality. Justice is a central principle of public health ethics (Gostin and Powers 2006): ideally, health promotion and preventive measures should reach the whole social spectrum of a population (Lehne and Bolte 2016) and thus increasing the overall level of health, rather than targeting subgroups of the population which may already be more privileged than others. But many policies aimed at promoting health do not always meet this requirement. In some cases, health promotion may actually increase inequalities between socially advantaged and disadvantaged groups (Cleland et al. 2012; Frohlich and Potvin 2008; McLaren et al. 2010). This phenomenon is sometimes referred to as "intervention-generated inequalities" (Lehne and Bolte 2016).

In what follows, we address the connection between self-monitoring applications and health inequality. First, we argue that self-monitoring applications can indeed aggravate intervention-generated inequalities. From the perspective of justice in public health, it is thus at least doubtful whether the proliferation of self-monitoring applications ought to be welcomed. In many cases, it remains unclear which subgroups benefit most from self-monitoring applications. Second, we show that self-monitoring applications are not generally morally reprehensible (even if they promote inequalities), and might create opportunities for public health if the problem of intervention-related inequalities is taken into account in the development of self-monitoring applications. Finally, we suggest strategies to avoid the aggravation of health inequality through self-monitoring applications.

Taken together, we believe that when properly designed, evaluated and targeted, persuasive self-monitoring applications *can* have many beneficial effects. In fact, the main upshot of our discussion will be to present a clearer idea of just when such applications have beneficial effects and how they should be designed and made accessible without detrimental effects on social justice.

2 Do self-monitoring applications increase health inequality?

One of the main moral aims of public health interventions is to promote the welfare of the population by improving their health (Powers and Faden 2006). Measures of public health are primarily supposed to maintain the health of the general population and its subgroups. A particular challenge, then, is to take into consideration the needs and preferences of the *individuals* included in the population. Promoting public health aims to achieve the best for the majority of people, but importantly, to achieve this goal *without cutting out the individual case* (Schröder 2007).

Yet, it is still unclear to what extent self-monitoring applications have a positive impact on the reduction of risk factors for chronic diseases (Albrecht et al. 2016). But first encouraging effects with respect to the use of such apps have been demonstrated with respect to lifestyle issues such as physical activity, diet and weight control (Carter et al. 2013; Glynn et al. 2014; Lubans et al. 2014). These points support the use of self-monitoring applications for preventive measures of health promotion and could justify a stronger political focus on a behavior-based health promotion (see below for details). However, let us emphasize that there is always a risk that structural measures take a backseat. This could be to the detriment of socially disadvantaged groups and aggravate social and health inequalities. Even though in the long run, almost everyone may benefit from digital devices with access to the internet, those with the most resources (status, cognition, education, income, access) adopt first, have and gain more skills, and use more and different activities more effectively (Pearce and Rice 2013). If it is true that the "rich get richer" it seems at least equally safe to assume that self-monitoring applications help "the healthy get healthier". Whether this presents a problem in itself or is subject to the well-known leveling down objection to equality will be addressed below.

On the assumptions that

1. self-monitoring applications have at least *some* beneficial effects for those who use them, and
2. the necessary financial, social and epistemic resources to obtain or use these applications are unequally distributed at the baseline level (that is, prior to the beneficial interventions mentioned in 1).

It seems to follow that

3. baseline-level health inequalities are *not alleviated* by self-monitoring applications, but rather
4. baseline-level health inequalities are *increased* by self-monitoring applications.

Call steps (1)–(4) the *argument from inequality*. In what follows, we will assume that (1) is correct. This move is justified (and empirically supported) because in this paper, we are not interested in discussing *whether* persuasive self-monitoring applications are effective, but what their effects on health inequality might be, *conditional* on the assumption that they are indeed effective. What evidence is there to suggest that (2), (3) and (4) may be true as well? For the claim that self-monitoring applications might not help alleviate inequalities in health, we present four arguments based on empirical findings and plausible, hypothetical considerations.

2.1 Resources

One major problem of self-monitoring applications, however, is the unequal opportunity individuals from lower status groups tend to have in making such technologies available for them. People need the financial resources to buy such devices, which are often expensive; they need the time to fit their use into their daily routines which often involve multiple jobs and tight schedules; and they need the knowledge and education to use such devices properly. For one, maintaining one's health as well as the adoption and maintenance of a healthy lifestyle requires financial, social, personal, environmental and educational resources (Abu-Omar and Rütten 2006; Armitage and Conner 2000; Bernard et al. 2007; European Commission 2013; Fors and Thorslund 2015; Grundy and Sloggett 2003; Hamilton et al. 2009; Huisman et al. 2013; Luszczynska et al. 2007; Read et al. 2016; Robert Koch-Institut 2016; Sallis et al. 2008). Numerous studies show that the burden is socially unequally distributed, as well as the resources to cope with it (Richter and Hurrelmann 2009). When resources such as knowledge, self-efficacy, and opportunities are already available, it is much more likely that the willingness to use self-monitoring applications is pronounced (Glied and Lleras-Muney 2008). Individuals with high SES accumulate the most benefit from their knowledge, efficacy, and resources in adopting innovative health-related behaviors and using emerging medical technologies (Glied and Lleras-Muney 2008; Link 2008). Quenzel and Schaeffer (2016) show that especially socially disadvantaged groups are constrained in making informed healthy choices and to participate in maintaining or regaining their health. For people who do not have such resources it is typically more difficult to change their health behavior (Lupton 2015); whereas people who do have such resources are in a position to benefit from using self-monitoring applications and to improve their already higher health level (DiMaggio et al. 2004).

2.2 Access

A second point suggesting that persuasive self-monitoring applications are seriously unequally distributed at the baseline level is that members of groups who suffer from fewer disadvantages have better *access* to new technologies. This phenomenon is often referred to as the "digital divide", which captures the idea that there is a fundamental divide in access to digital information due to the demographic makeup of groups (DiMaggio et al. 2004; Lorence at al. 2006). Statistics from the Pew Research Internet Project (2014) show that mobile devices have been widely adopted across demographic and ethnic groups. Worldwide sales of smartphones are estimated at 1862, 3 Million for 2019 (idc.com, 2015). In Germany, 63% of the population own some kind of mobile device (Weicksel and Pentsi 2015). In America, cell phones are being used by 91% of adults (Rainie 2013) and 64% of American adults are smartphone owners (Smith 2015). Compared to previous years, the number of users is increasing significantly (Smith 2013, 2015; Weicksel and Pentsi 2015). Smartphone ownership is particularly high among younger adults and those with relatively high levels of household income and educational attainment. Especially for older smartphone users (65 and older), ownership is more of an "elite" phenomenon (Smith 2013). For people of age 65 and older, those who did not attend college, those living in households earning less than $30,000 and those in rural areas have less access to smartphones and thus to self-monitoring applications (Smith 2015).

According to a German study, digital health care and services in the areas of fitness, tracking and monitoring are also currently being used by younger age groups (Statista 2015). However, across different target groups, digital health applications are rarely used with great intensity. The use of health care applications on smartphones alone does not appear to be a sufficient proxy for access to self-monitoring applications. Health literacy and computer literacy, as well as health-related search behavior must be considered as well. In particular, people with a migrant background, low levels of education, low social status, chronic illness, and in older age have comparatively limited health literacy (Schaeffer

et al. 2016). Health- and computer literacy, respectively, and thus health information seeking behavior is beyond the reach of many older, disabled, or low-income individuals. It remains true that the basic use of mobile devices as well as the specific use in health contexts are partially dependent on sociodemographic factors (Albrecht et al. 2016). Bodie and Dutta's *Integrative Model of eHealth Use* (Bodie and Dutta 2008) is useful to describe the divide in access to self-monitoring applications. This model suggests that the motivation and the ability for online health information seeking behaviors diversifies depend on disparities in social structures such as socio-economic, situational, personal and cultural factors (Lee et al. 2014) and that "structural inequities reinforce themselves and continue to contribute to healthcare disparities through the differential distribution of technologies that simultaneously enhance and impede literacy, motivation, and ability of different groups (and individuals) in the population" (Bodie and Dutta 2008). Health literacy and computer literacy are predictors of online health information-seeking behaviors and health behaviors (Lee et al. 2015). Moreover, studies regarding the general population in the USA have confirmed that being male, older, and having lower education are negatively associated with health information seeking behavior (Koch-Weser et al. 2010; Lustria et al. 2011). The Lancet (2017) brings that to the point: "The higher rates of smartphone ownership and digital literacy in younger, wealthier populations and the predominance of English language apps have created relative digital disenfranchisement among those with the greatest need." (The Lancet 2017).

2.3 Targeting

The third argument for the claim that self-monitoring applications might not help alleviate inequalities in health is that the development of persuasive strategies is often specifically *targeted* to the needs of less disadvantaged people, as these people tend to be relatively affluent early adopters and consumers. Usually, self-monitoring applications are developed in light of anticipated user profiles. However, there is a risk that these profiles paint a one-sided picture of the prototypical user. It is likely that people from socio-economically disadvantaged backgrounds are least likely to participate in survey research (Turrell et al. 2003). This can also be assumed for participation in requirements analyses for app-usage. Therefore, the needs of disadvantaged people are generally not sufficiently represented or addressed (Albrecht et al. 2016).

2.4 Incentives

Finally, when incentives such as lower health insurance premiums are offered to those who opt in and use self-monitoring applications in an effective manner, financial discrimination for those who are not able to use self-monitoring applications in an equally effective manner is involved, thereby doubling down on existing inequalities (see Oliver and Brown 2012 for a series of concrete examples).

In this first section, we focus on arguments supporting the hypothesis that self-monitoring applications can contribute to problems of social justice by promoting baseline social inequalities.

3 Are self-monitoring applications morally objectionable?

In light of the above arguments that self-monitoring applications do not alleviate or even aggravate health inequalities, the question arises as to whether self-monitoring applications are morally problematic. Let us consider four objections why self-monitoring applications are not generally morally objectionable.

First, one may ask whether the problem of intervention-generated inequalities is *specific* to persuasive self-monitoring technologies, or whether it applies to all (or at least most) newly available technologies? Consider the following example: when they were first introduced, washing machines, which have a tremendously simplifying impact on one's daily chores, were only available to the affluent. Does this make using washing machines morally wrong? Note that this brief sketch of an argument does not show that persuasive self-monitoring applications are off the moral hook: it merely shows that, whatever we should have said about washing machines then and other more familiar technologies, we should say the same thing now about less familiar technologies such as the ones discussed in this paper.

On the former view, inequality may be *pro tanto* objectionable, but nevertheless all-things-considered acceptable on account of being without a serious alternative. Friedrich Hayek, for instance, argued that new technologies are always first made available to the rich, who inadvertently pay for the society-wide distribution of certain goods and technologies[1].

[1] "Our rapid economic advancement is in large part a result of inequality and is impossible without it. Progress at a fist rate cannot proceed at a uniform front, but must take place at an echelon fashion […] At any stage […] there will always be many things we already know how to produce but which are still too expensive to provide for more than the few. […] All of the conveniences of a comfortable home, of our means of transportation, and communication, of entertainment and enjoyment, we could produce a first only in limited quantities; but it was in doing this that we gradually learned to make them or similar things at a much smaller outlay of resources and thus began to supply them to the great majority. A large part of the expenditure of the rich, though not intended for that end, thus serves to defray experimentation with the new things that, as a result, can later be made available to the poor" (Hayek 1960, 42–44).

If this is correct, then inequality is *instrumental* for bringing about social and technological progresses that makes everyone better off in the long run. On the other hand, this argument already *assumes* that there is inequality, the existence of which it takes as given: it shows that *when there is inequality*, the best way to make new technologies widely available is to make the affluent pay the up-front costs. It does not entail that it would be impossible for a radically equal society to make any technological progress.

Second, one could argue that the view that inequalities are objectionable relies on a misleading account of how society works. Schmidtz (2011), for instance, suggests that we ask not whether there are inequalities per se, but whether inequality-generating improvements of some people's position come at *anyone's expense*. Sometimes, the answer will be 'yes', for instance, when two people with different talents compete for the same job. In general, however, society is a "cooperative venture" rather than a zero-sum game in which one person's gains are the other person's losses[2]. In some cases, the worse-off *benefit* from inequalities, because the healthier, smarter, stronger create products and services which benefit everyone, and thus make people's lives better. It is clearly correct that due to its cooperative structure, society, even an unequal one, makes us better off than we would be if stranded on a desert island. On the other hand, this argument ignores the fact that the wealthy and well-connected also often rig the system in ways that harm, rather than benefit, the worst-off (Pogge 2014).

Third, the well-known "leveling down objection" to equality as a good worth promoting for its own sake applies in an adjusted version to the problem at hand (and bears some similarities to the previously made point, albeit embedded in a different theoretical framework). The primal idea of the leveling down objection is that if equality is achieved by adjusting the level of the better-off to the level of the worse-off, nobody benefits. To the contrary, the overall level decreases. What good, then, does equality do, if it doesn't help anyone? This objection indicates that promoting equality (or doing away with inequality) is worthwhile only (or at least mainly) inasmuch as it helps improving the overall circumstances in a given society (Nozick 1974; Raz 1986; Temkin 1993). Whereas equality in and of itself, regardless of what happens to the overall level, cannot be a morally decisive reason for the provision of goods—particularly if the provision of goods that are (at least initially) only available to a few is not to the disadvantage of those who have no access.

An argument similar in spirit to the leveling down objection applies to self-monitoring devices. Promoting equality for its own sake cannot be a good reason for suggesting such devices to be morally wrong. Since, if the so achieved equality comes about by taking away potential benefits from a few—and in some sense thus leveling down the potential beneficiaries of these technologies to the level of those that are currently not potential beneficiaries (for financial or other reasons)—nobody benefits. Or, slightly adjusting the argument so as to allow for a positive claim: while it might be true that these devices do not alleviate the overall inequality of public health, and perhaps even increase the overall inequality thereof, they do at least help increasing the actual health of some without thereby decreasing the actual health of others (unless of course seen in relative terms). Thus, using such devices might be morally acceptable even if there are currently only few beneficiaries of such technologies and they do not promote equality.

Fourth, we have seen that some have argued that the problem of health inequalities cannot, and should not be targeted via individualistic mechanisms at all (Lorenc et al. 2013), see above. Public health cannot be improved using technological devices used by individual consumers, but should rather be addressed by *structural change* that tackles the root causes of various prevalent health concerns. We agree that this is a legitimate point, but does it show that such technologies are morally problematic to use? In general, the fact that structural solutions would be preferable to individualistic ones does not show that individualistic solutions are morally wrong, at least not when such structural measures are not politically available or otherwise not feasible. Compare: the fact that a doctor working in a military hospital does not tackle the root causes of war (McMahan 2016) does not make the doctor's actions morally objectionable, given the fact that an individual doctor cannot just end the war instead. Similarly, individualistic interventions which provide benefits to some people are at least morally *permissible* when structural reform is difficult or impossible to achieve. It then remains a further question whether self-monitoring applications make structural change *less likely*, or whether they tend to slow them down in the long run.

The above considerations in Sect. 3 suggest that the question of whether social (in)equalities should be welcomed or opposed does not have a simple answer. We wish to emphasize, however, that this does *not* entail that pursuing social equality, and alleviating inequality, cannot be desirable political goals, regardless of whether the debate on the moral (ir)relevance of equality has been settled once and

[2] "One way (the only way we know of) to rationalize the idea that *Jane's* being more talented than *Joe* entitles Joe to compensation is to suppose that life is like a zero-sum poker game in which the more talented Jane is, the less chance Joe has of winning. […] However, […] society is not a zero-sum card game, but a cooperative venture in which the pie's size is variable. Almost all people can have a better life than they could have had on their own, and the reason is simple: Other people's talents make all of us better off. Talented bakers don't just capture pie. They *make* it. The rest of us have more pie, not less, when talented people put their talent to work" (Schmidtz 2011, p. 219).

for all. The key thing to realize is that social equality can be conducive to *other* states of affairs that *are* inherently politically desirable.[3][4]

To optimize the development and implementation of self-monitoring applications from the perspective of public health, it might be needed to avoid the promotion of health inequalities through self-monitoring applications.

4 Approaches to avoiding the promotion of social inequalities through persuasive self-monitoring applications

If the suggestion that social inequalities should be avoided and/or alleviated is warranted, *how* could this be done? This is obviously the central issue from a public health perspective.

Some authors argue that health policy interventions focusing on social or structural changes are less likely to increase inequality compared to interventions focusing on individual behavior changes (Lorenc et al. 2013), and are thus preferable. Call the former type 'upstream' and the latter 'downstream' interventions. Lorenc et al. (2013) further point out that there is robust evidence that some public health intervention types (for example, media campaigns, printed communication materials) increase inequalities between socio-economic groups, while various other intervention types (for example, structural workplace interventions, provision of resources, fiscal interventions) appear promising in reducing inequalities. Recent reports highlight the continuing importance of tackling economic and regulatory environments to reduce health inequalities (Marteau et al. 2011). For example, pricing interventions and regulation of food labeling and marketing are likely to produce the largest health gains (Cecchini et al. 2010) and increasing the price of tobacco seems to be more effective in reducing smoking among adults with lower than among those with higher incomes (Thomas et al. 2008). These findings should be kept in mind while planning interventions focusing on individual behavior changes with the aim of improving the quality of life and the health for a wide spectrum of a population.

In general, downstream interventions are more likely to increase inequalities than 'upstream' interventions (Lorenc et al. 2013; Macintyre 2007; White et al. 2009). Interventions with persuasive elements such as self-monitoring applications qualify as 'downstream' interventions which focus on individual behavioral changes and on individual responsibility for one's own health. The effects of these interventions depend on users' literacy, numeracy, and cognitive control, which are generally poorer in those who are more disadvantaged (Marteau et al. 2012). These interventions providing persuasive information typically pay little attention to the broader socio-cultural and political context in which individuals act and are predominantly based on traditional psychological models of behavior (Lupton 2015). What we suggest, then, is to widen the focus and pay more attention to the broader socio-cultural and political context within which individuals act. Here, to use just one possible example, the so-called PROGRESS framework (O'Neill et al. 2014) provides a useful metric. Starting from an individual's social situation and current health literacy, this framework can be used to identify factors such as health-related resources and deficits. Thus, persons could be identified with regard to their access to health care and personal resources and so appropriate and realistic recommendations could be made. Persuasive strategies could then be more targeted to different social groups with respect to the needs of the individuals in these groups. Structural conditions such as socio-ecological and socio-economic factors are of towering importance for the development and implementation of self-monitoring applications. Consider the striking and frequently mentioned fact that, for instance, the life expectancy of people who live in the poorer parts of Glasgow is reduced by 12 years as opposed to residents of more affluent neighborhoods (Shaw et al. 2000). This extreme disparity simply cannot be explained by the impact (or lack thereof) of *ex post* health *care*, and must, at least to a large extent, be due to structural factors such as living and working conditions (Segall 2009). Self-monitoring technologies could be used for tracking environmental data (e.g., noise, pollution, accessibility of green areas and recreation facilities). Such an approach could help to derive measures which at least do not *exacerbate* social inequalities while promoting the health of the general population. The problem with this, however,

[3] Most importantly, massive inequality can undermine institutions of democratic deliberation: for one, individual command of considerable financial resources can make governments' decisions dependent upon special (e.g., corporate) interests; for another, a lack of resources can skew the political process by limiting equal access to the political arena for less resourceful individuals (Cohen 1989). Social equality can thus remain an indirectly important ethical value even if its intrinsic moral relevance is limited (Frankfurt 2015) (Frankfurt 1987).

[4] On perhaps the most influential framework for understanding social justice, inequalities can be justified when, and only when, they are to the benefit of the worst off. This is called the "difference principle" (Rawls 1971). It may, for instance, be justifiable for doctors to make more money, because the work of doctors is good for everyone, especially the worst-off, so doctors may demand to be paid more than others, which leads to inequality (for criticism of this "special incentives" argument, see Thomas (2012)). One way to cash out this idea would be to suggest that as rich individuals become even healthier, this lowers the costs of health care provision for everyone and increases productivity, which ends up being in the interest of the poor. Then again, whether this is so is an empirical issue. It is also a political one, since although it is possible for the resources so freed up to be used in this way, it is an open question whether they would in fact be.

is that the collected data must be stored centrally and evaluated. This raises questions of jurisdiction. Furthermore, environmental desiderata identified in this way must lead to concrete policy measures in the form of structural changes to create health benefits. Such structural changes could be time consuming and expensive and do not directly benefit the health of individuals. The motivation to participate in the collection of data could therefore be low, since a benefit for the individual probably occurs much later.

Following the conclusion of some authors that 'downstream' interventions are more likely to increase inequalities than 'upstream' interventions (Lorenc et al. 2013; Macintyre 2007; White et al. 2009), implicit intervention strategies such as nudging continue to be promising (Department of Health 2010; Thaler and Sunstein 2008). Marteau et al. (2012) propose that interventions targeting the automatic processes of behavior may be more effective than encouraging people to reflect on their behavior. Changes can be made to make people healthier while alter a person's environment, or special training programs can help to decouple disastrous associations—such as television and chips—and replace them with new, healthier ones. The latter one aims to target automatic processes and individuals' responses to environmental cues.

Nudging refers to changes in a decision situation that promotes a certain behavior without restricting decision-makers in their (Marteau et al. 2012) freedom of choice and self-determination (Thaler and Sunstein 2008). Despite the criticism this approach has received, the prospect of being able to nudge populations into changing their behavior has generated great interest among policymakers worldwide (Marteau et al. 2011; Reisch and Sunstein 2016). Decisive for the acceptance of nudging, according to Reisch and Sunstein (2016), is the approval of the goal or target behavior. To improve a population's health and the health of individuals is a widely accepted goal and the idea of public health. Nudges to promote physical activity could be more attractive stairwells or slowing down the speed at which elevator doors close and thus increasing the journey time (Marteau et al. 2012). Nudges can also help to break harmful habits in food choices. With an attractive supply of fruits and vegetables as dessert, for example, they often abstain from ice cream and other sweets. The selection of easier-to-reach food options can be increased while altering the effort required to reach foods by manipulating their proximity (Marteau et al. 2012). There are indications that children and adolescents buy more fruit during school breaks when they are placed next to the cash register. The availability of options within environments meets the WHO Requirement formulated in the Ottawa Charter for Health Promotion: Make the healthy choice the easier choice (WHO 1986).

Gigerenzer (2014) suggests yet another strategy, namely to increase people's *risk competence*, rather than explicitly telling them what to do. Nudging, as a sole strategy of behavioral change can create a harmful dependency on the so-called health experts. This dependency could be softened by supporting and training people to make the right decisions by providing the most important facts, combined with basic risk literacy. Following the argument of Gigerenzer, nudging alone, may be not the appropriate strategy. To take responsibility for one's own health, each individual should have sufficient health literacy. Marteau et al. (2012) therefore stress the potential of nudges to reduce health inequalities, since they do not rely on the communication and comprehension of complex information. For targeting primary automatic associative processes and for designing special training programs to help decouple the undesirable associations, environments could be provided with digital nudges using *augmented reality* (Liberati 2016). Digital nudging has received much attention in the recent past, as it has positive findings from behavioral science, to improve acceptance, use or awareness (Stieglitz et al. 2017). Digital nudging in augmented reality can be used to activating or inhibiting existing associations between an environmental cue and the behavior and could support training to inhibit behavioral impulses to engage in unhealthy behaviors (Nguyen et al. 2014). The aim could be to influence people who have made the intention to change their health behavior in decision-making situations with regard to a health-promoting behavior by, for example, presenting a behavioral standard ("95% of other people in your circle of friends have made this choice") or the virtual environment is adjusted (eg by virtually nicer staircases, unattractive elevators). Both strategies, nudging and increasing health literacy, seem to be promising approaches to avoid the promotion of social inequalities through self-monitoring applications and to support the individual responsibility for one's own health.

To adequately address behavior support through self-monitoring applications, we propose a human-centered, personalized and context-adaptive support to promoting health-related behaviors. A human-centered methodology ensures that "users" and other stakeholders are involved in the creation of self-monitoring applications to meet the stakeholders' demands. Based on Albrecht et al. (2016), political actors, developers, users and healthcare professionals can be identified as stakeholders in the design of health apps. Considering the diversity of stakeholders beyond end users could be critical for product adoption (Tanaka et al. 2015). Complementary to other design research approaches, for example, User-Centered Design (USD), Participatory Design (PD) or Design-Thinking-Action Research (AR) is a suitable methodological framework to address practical problems to an individual or group due to its iterative nature (Tanaka et al. 2015). In a first step (1), AR might help to identify a relevant health problem (for example, hypertension) or an improvement opportunity in the health behavior

of an individual (for example, the consuming frequency of certain food groups or the sedentary behavior). In step (2) AR alternative courses of action are considered to attain the improvement or solve the problem identified (for example, to enhance the vegetable or fruit consumption or the physical activity). In a third step (3), an action is selected and implemented (for example, enhance physical activity while presenting a behavioral standard of the physical activities of others). Then the outcomes are analyzed in the Evaluation step (4). From the conclusions and the identified knowledge, a (5) model is built (for example, "During the evaluation period of four weeks, the user increases his/her physical activity by 50% the following day after getting a behavioral standard of the physical activity of his/her friend presented in the app each evening") to describe the situation under study and to inform the second iteration phase in step six (6). To this end, a greater awareness of different opportunities for the improvement of healthy behaviors and a higher sensitivity for the demands of various stakeholders is required during the development of persuasive health-monitoring applications.

The goal of self-monitoring applications should be to make people feel well, healthy and competent in terms of their health. According to the above arguments, socially advantaged individuals or groups may need less support in achieving this goal than disadvantaged individuals or groups. Being able to respond to the needs of each person helps everyone and does not widen the gap between socially advantaged and disadvantaged individuals or groups. It might even be argued that such context sensitive interventions potentially amount to a "levelling up" of the opportunities of people with lower economic status to those of the affluent as they promote and increase the overall level of healthy lifestyle choices.

5 Conclusion

In this paper, we assessed the ethical discourse of the propensity of self-monitoring applications to increase health inequalities, thereby creating a problem of social justice.

Our paper has three main sections. In the first, we review the available evidence regarding the inequality-promoting effects of self-monitoring applications defined as interactive computer systems designed to change the health behavior and attitudes of their users. Based on the results of several studies and reviews, we hypothesize that less disadvantaged groups benefit more from persuasive health-monitoring technologies (as a digital health promotion strategy) than more disadvantaged groups. We state that, given certain baseline social inequalities that already exist, lifestyle interventions using self-monitoring applications are ill-equipped to alleviate such inequalities, and tend to make them worse. Here, we distinguish four factors that could be responsible for this unfortunate tendency: resources, access, targeting, and incentives. In Sect. 3, we consider objections why self-monitoring applications are not generally morally objectionable. People nowadays believe that a concern for equality has little or no moral relevance (Frankfurt 2015). We argue that if possible, lifestyle interventions based on self-monitoring applications, but also lifestyle interventions more generally, should be designed to avoid the promotion of social inequalities. In Sect. 4, we suggest ways to avoid the promotion of social inequalities through self-monitoring applications: (1) to pay more attention to epistemic, socio-economic and environmental circumstances in which individuals act, (2) to use strategies of digital nudging to activating or inhibiting existing associations between an environmental cue and the behavior and (3) to personalize the support of health literacy and health behavior while using human-centered methodologies in the development of self-monitoring applications.

To enhance the effectivity of self-monitoring applications regarding the prevention of lifestyle-induced diseases through different populations, developers, consumers, policy makers, and physicians require to recognize that apps must be assessed like every other clinical intervention and that evidence-based efficacy, cost-effectiveness, and accessibility must be prioritized alongside technical software development (The Lancet 2017).

Our findings have some limitations. In particular, our work relies on hypothetical considerations and descriptions which we provide with empirical evidence. Cross-sectional studies, longitudinal and intervention studies will be required if causal relationships are to be inferred.

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