Mobile, Wearable…Ingestible: Reflections on Future Critical Research Agendas in mHealth

Abstract

This article presents a review of critical research on mobile and wearable health technologies. It focuses on lifestyle applications, drawing attention to key governmental and policy interests in the trend towards greater digital integration in health care. In so doing, it outline show research has identified key concerns regarding inclusion, social justice, and ownership of mobile health data, which provoke a series of key sociological questions that are in need of additional investigation. It also discusses the expansion of the parameters of what counts as health data, as a basis for advocating the need for greater research into this area, notably considering how digital devices reconfigure relationships, behaviours, and a sense of individuality.

Introduction

In present times, health care is being radically reconfigured by the growth of mobile and wearable technologies, which allow people to self-monitor and regulate their health practices, often without the involvement of any healthcare professional. For example, wristbands fitted with motions sensors use algorithms to track everyday activities, such as walking or hours slept. The global significance of these transformations is vast, as mHealth activity is capable of functioning in environments where there is a limited technological infrastructure. Thus, studying mHealth is fast becoming a global priority, especially where resources are limited and where more people have access to a mobile device than a hospital or clinic. While there is much to celebrate about the transformative potential of mHealth, there is also a more critical discourse emerging in response to what Lupton (2014, p706) describes as the "prevailing solutionist and instrumental approaches to the application of digital technologies to medicine and public health".

To extend the critical analysis or mHealth, this paper examines consumer-oriented technologies that are pertinent to promoting healthy lifestyle behaviours, such as physical activity, body weight management, and food consumption. Our interest in these categories of mHealth technologies is informed by wider concerns about the absence of regulation around such lifestyle apps (Powell, et al, 2014). Over 70% of all health apps fit into this category (Research2Guidance, 2014), but the expansion of health related data reveals a much bigger picture of unregulated health apps. This paper presents an overview of critical digital health studies focused on these technologies and signposts future research agendas. Our analysis begins with a review of the term mHealth, so as to establish the parameters of this field. We then focus on some of the recent notable contributions to the critical analysis of mHealth, theoretical developments and explore some of the challenges and emerging issues. Whilst many of these wearable technologies and apps deserve individual empirical exploration - perhaps even the development of what might be termed *device ethnography* – we offer some observations about the characteristics of these apps and the kinds of practices that occur within them. These insights raise broader questions about whether the sociology of digital health, as a distinct research field is in need of new methodological approaches, or whether conventional approaches can simply be adapted to digital communities.

The emergence of mHealth as a solution to public health problems

Striving for technological efficiencies has long since been part of healthcare's internal logic. As such, the recent trend towards adopting mobile health tracking technology must be understood within the wider

economics of care, which tend towards streamlining structures and systems. Increasingly, governments and health agencies treat mHealth as a way to deliver a more efficient and effective health care system. In 2014, the British Government's vision statement for transforming health care in the face of a growing budget deficit, notes that it will develop an "expanding set of NHS accredited health apps that patients will be able to use to organise and manage their own health and care" (NHS England, 2014, 32). For the UK, it is perhaps the clearest indication of how the mobile device ecosystem will become a bigger part of how healthcare is managed. The rising appeal of digital health solutions to influence individual behaviours is therefore rationalised "against the backdrop of contemporary public health challenges that include increasing costs, worsening outcomes, 'diabesity' epidemics, and anticipated physician shortages" (Swan, 2012; 93). Policy investments in digital healthcare are justified on the basis of their ability to deliver greater efficiency of overburdened health-care systems. In terms of how health-care is practiced, it therefore reflects a logic of choice (Mol, 2008) whereby the concept of the patient as a customer or citizen emerges, along with the instrumental aspirations of digital interventions that transfer responsibility away from the state and onto the individual; an approach which as many of the studies below indicate, aligns with the neoliberal health perspectives. Governments and health organizations are recognizing the opportunities - and additional responsibilities - afforded by these technologies, as a means of delivering more effective health care systems (European Commission, 2010) and as a way of fostering a "digitally engaged patient" (Lupton 2013a).

The ubiquity of mobile devices, combined with the app ecosystem, has secured their place as a core driver of preventive health medicine, now recognised as 'mHealth' (Lupton, 2012; WHO, 2011). According to the WHO (2011), mHealth includes "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices" and is a major growth area within health. In these new territories of health engagement, there is a growing market in mobile health apps categorised as 'lifestyle', and it is this category of mHealth technology to which we turn our attention. These apps allow users to track their exercise behaviour, body weight, and food consumption and are the most downloaded health apps across devices (Fox and Duggan, 2013). Such is their growing popularity and use, Google announced 2014 as the year of health and fitness apps (Boxall, 2014) recording this as their fastest growing app category, a statistic reinforced by Research2Guidance (2014), which identifies the health and fitness category as the largest of all mHealth groups, with around 30% of the total share. Furthermore, Ruckenstein (2014, p. 68) observes that "smart phones and tracking device have created a field of personal analytics and self-monitoring practices". Users learn how to look after themselves via the disciplining regularity of the device's presence, with its regular notifications, which encourage attentiveness to good behaviour; a trend that has being termed 'nag

technology' in popular culture. This growth in self-monitoring is also being enabled by the proliferation of wearable technologies, such as fitness bands (FitBit, Jawbone, Misfit), which include sensors, such as bands, patches and GPS technologies to enable logging of data from a user's movements and behaviours, such as body mass index, calories burnt, heart rate, physical activity patterns.

The rapid development of new technologies, their modes of organizing data on bodies and the use of collective 'big data' may demand the development of new theoretical approaches and methods. Health data produced both inside and outside of medical sites challenge the norms within different contexts of health and wellness, including previously defined distinctions between patient and consumer, device and data, and health care and personal wellness. It is no surprise, therefore, that sociologists are turning to studies of health interactions in digital environments, as mobile and wearable technologies become a feature of everyday life. Indeed, the end point of this trend seems likely to be the emergence of ingestible sensors – or ingestibles – of which the first was granted FDA approval by Proteus technologies in 2015 (Proteus 2015)

Quantify and Know Thy Posthuman self: Self tracking and the Quantified Self

A number of studies examine a series of deeper trajectories that underpin the development of mHealth technology and the kinds of self-tracking behaviours that they nurture. Reflecting health and medical consumerism (Henderson and Petersen, 2002) self tracking technologies offer market solutions to health problems whereby users can purchase, for example, apps to capture data about their bodies and therefore, hopefully, make more informed decisions about their health. A number of authors elaborate on these concerns by examining the overarching shift towards the personalization and individualisation of healthcare through the self-tracking practices of mHealth technologies. To draw upon Foucault's concept of biopower, self-tracking and self-regulating through mHealth can be articulated as subjects engaging in "technologies of the self" (Foucault, 1988) to adhere to discourses of normalization of the body. In the case of mHealth, health practices are rendered visible through capturing body data. Via processes of quantification and visualization, this data is transformed in such a way so as to classify bodies in terms of worth or achievement, reflecting the processes of biopower (Focuault, 1988). Ruckenstein (2014) suggests that this form of 'personal analytics' is therefore tied to notions of control and governmentality. Within this framework, health becomes the responsibility of the citizen as a productive consumer, whereby they become primarily responsible for their own health. To understand this more, authors are turning to theoretical concepts of pedagogy to explain how this form of biopower operates. For example, Williamson (2015; 140) investigates how self-tracking technologies are framed as 'biopedagogies of

optimization' (Williamson, 2015; 140) through which 'self-quantification represents a new algorithmically mediated pedagogic technique for governing and ordering the body'. Alternatively, Rich and Miah (2014) examine the public pedagogies of mHealth, calling for more research into understanding what and how people learn about their bodies and health through self-tracking and quantification. These sociological approaches are revealing the impact of mHealth technologies on people's subjectivities and bodies in ways that may be cause for concern.

More recently, new modes of quantifying the body and capturing data have promoted debates about ontological assumptions regarding how bodies are experienced and rendered knowable. For instance, Ruckenstein (2014: 71) suggests that 'self-tracking tools abstract human bodies and minds into data flows that can be used and reflected upon' (ibid, 2014: 71). This work has revealed the processes of 'datafication of the body' (Mayer-Schönberger and Cukier, 2013, p. 48) where users are prompted to explore their datafied self, as a 'data double' (Haggerty and Ericson, 2000; Ruckenstien, 2014) so as to acquire knowledge of their bodies and purposefully monitor and regulate their health and body practices in line with related norms. A body of work has therefore focused on the way the body is being rendered knowable (Gilmore, 2015; Millington, 2015) through numbers, or as Gilmore (2015 p.3) phrases it "adding increasingly quantifiable means of accounting for one's being in the world". Such work positions mHealth as converging with neoliberal strategies of governance, promoting autonomous, enterprising individuals who are encouraged to capture data, share, analyse and reflect on it in relation to data norms. A number of authors describe how the body becomes knowable as an object of quantified knowledge, reflecting a 'techo-utopian' view of the body (Lupton, 2014a). Increasingly mHealth is therefore positioned as a means to achieve 'self betterment' or 'self-optimization' (Ruckenstein, 2014, p.69) whereby it is not enough to 'have a more transparent view of oneself, one needs to respond to that knowledge and raise one's goals'. Thus, mHealth technologies focused on lifestyle emphasise our ability to enhance one's physical or mental capacities, orienting individuals towards practices of monitoring, regulation but then also adaptation in the pursuit of an increasing emphasis on 'wellness' (Fries, 2008). In doing so, this neoliberal logic of the knowable body is part of a broader culture of risk management demarcating a shift towards 'posthuman optimisiation' (Millington, 2015).

The relationship between consumption and health has been addressed within the wider literature within sociology of health (Fries, 2008). Extending this work, mHealth technologies are prompting new questions related to our understandings of 'humanness' and the relationship between the body and technology (Lupton, 2014b; Miah and Rich, 2008; Millington, 2015;). Indeed, wearable technologies, such as fitness bands and wearable devices with biosensors to monitor our bodies are rapidly being

characterised by a whole range of devices and distinct features (Alrige and Chatterjee, 2015). Again, one of the key aspects of mHealth is the growing autonomy of the device and the seamless capture of data about our health. This is indicated by the integration of activity monitoring in such platforms of Apple, with its built in *Health Kit*, or Samsung with its *S Health* environment. In each of these cases, the device comes pre-loaded with the requisite tracking technology. While one can switch it off, the default position upon purchase is for it to be on and monitoring what we are doing - predicated on what we described earlier as the neo-liberal desire to be good citizens and keep an eye on how we are doing. Drawing on the analytical work of Galloway (2004) of 'everyware' technologies, Gilmore (2015) develops the concept of 'everywear' technologies, described as those 'wearable' technologies, specifically within the fitness industry that reflect the ubiquitous technologies, "tethered to bodies and, through habitualization, designed to add value to everyday life in the form of physical wellbeing" (Gilmore, 2015, p.2) Elsewhere, in his critical examination of wearable posture-tracking technologies, Millington (2015) observes that "new posture technologies trade optic for haptic surveillance. Sensors replace the eye with the touch en route to amassing extensive data on where posture goes 'right' and 'wrong'". Through their ubiquity and automatic generation of data, he argues, "surveillance is 'passivised' as users do not so much participate as they do generate" (Millington, 2015, p.6).

Such studies and the widespread use of these 'everwear' (Gillmore, 2015) technologies raises a series of questions about the autonomy of the device itself, reflecting a broader shift towards the 'sensor society' (Andrejevic & Burdon, 2015). No longer would it be necessary to take out a device, open it up, turn it on, and navigate to the information we seek. Instead, the occupation of the device on our person, within our sensorial environment, allows it to function as if it were part of our body. Rich and Miah (2014, p.308) describe this as "posthuman technological mediation and prostheticisation", through which "new sensorial experiences, such as the wearing of fitbit health bands, which vibrate when you achieve your activity goals, combine different pedagogical forces to produce embodied ways of knowing".

Alongside this is the development of the internet of things - a world in which devices are connected to the Internet. Presently, the approach to mHealth is mostly centred on the person of the user - their body literally. Yet, it is likely that an individual's body will become just one unit in a wider connected system, as captured in the work of Williamson (2015, p.147) who suggests that "rather than the cyborg image of the artificially prosthetized body, self- tracking connects bodies into a web of data, analytics and algorithmic forms of power—a 'corporealgorithmic' coupling of bodies and flows of data". These developments require theoretical approaches that can explore not only the relationship between sensory experiences and technology, but also "the sociocultural constructs that also affect bodies materially" (Fox,

2016, p.67):

> "New materialism's relational and 'flat' ontology (in common with post-structuralism) eschews any notions of social structures, systems or mechanisms that can 'explain' social action and interactions. Instead, it explores the world and human lives by exploring how natural and cultural relations assemble, the forces (affects) between them and the capacities these affects produce" (Fox, 2016, p.70)

On this view, whilst constructionist and post-structuralist approaches to mHealth may reveal important insights about the power and constitution of the subject of quantification, 'new materialisms' focused on 'matter and the materiality of social production' (Fox, 2016; 67) may provide new insights into pressing questions about mHealth: how does the quantified, self-optimised body 'affect' other bodies (Deleuze, 1988), such as those in schools or in the workplace? How does rendering the body knowable through quantification impact upon the body's capacity - how does the sensory experience of wearing technology shapes what they body feels like and what it can do? As the capacity of the body becomes knowable through quantification, what is the capacity for it to form relations with others? How do such relationalities come to impact on our understandings of relationships in health such as those of the patient-professional? From this perspective, Fox (2011, p.366) argues that health can be understood as the "proliferation of a body's capacities to affect and be affected". In other words, whilst it is important to understand what the quantified bodies come to represent, the ontological orientation of new materialism or sociomaterialism would open up questions about what the body can *do* to other bodies in assemblages of quantification

Critical Questions on mHealth, Big Data and the Consumerism of Health

The consequences of the biopolitics of mHealth are only just beginning to be understood.   A specific feature of mHealth applications and the data they generate is its capacity to be shared with others, for example with within social media networks. There is a pressing need to address the public facing imposition of the mHealth industry, exacerbated by this 'sharing economy' (Barta and Neff, 2016) in which smart device users operate. How are we to conceptualise what is seen as an erosion of the public/private divide? To this end, mHealth does not simply respond to a vision of health, but can also be considered characteristic of a — 'confessional society' (Bauman, 2007). With their accompanying processes of surveillance and evaluation, these technologies imply certain, learned expectations of control, which are to be publicly displayed for evaluation by others as part of a process of 'lateral

surveillance' (Andrejevic, 2005). Thus, for example, the act of sharing the route, time, and distance of one's run, while being monitored by Runtastic, becomes a matter of shared knowledge, a matter of public dissemination or declaration, rather than of private record.

Apps and wearable devices can produce digital data on various bodily functions. Such data is not only shared via social media, but also forms part of a broader 'digital data economy' (Lupton, 2013b: 30) in which companies and health organisations are interested in the broader utility of such data, when aggregated across a user community. As 'entrepreneurs' (Rose, 1999) continue to develop the digital market for health with new interfaces, critical digital health studies will need to address crucial issues concerning institutional use of data and this is pertinent especially since users operate at a very individualistic level, without much sense of how their broader community is being exploited. To that end, we concur with Till (2014) that sociological approaches to digital self-tracking have tended to be focused at the micro level in terms of the surveillance of individuals, subjectivity and the relationship to the self and body. More recently, there are emerging questions and critiques of the ways in which corporations manage data, processes of digitization and quantification, particularly with the rise of 'Big Data'. Some authors are beginning to reveal the socio-cultural implications of data mining and the collection of data on users that is used for marketing and other purrposes (Till, 2014; Lupton 2014b). Yet, there are many other questions to address. For instance, future studies of mHealth might find synergies with the studies of leisure sociology, in terms of the blurring of boundaries between work and leisure and the role of consumption through mHealth, particularly through processes of what Whitson (2012) describes as 'gamification'. Recognising the processes of gaming with many of the mHealth technologies, emerging work is beginning to explore this conflation between 'work and play' (Till, 2014) and the extent to which "corporations have successfully convinced users that it is leisure, not labour" (Till, 2014, p.449), despite the monetization of data. This blurring of the distinction between medical data and the commercialization of health and wellness raises a number of questions which sociologists can help answer. For example, sociology can shed light on questions of data ownership, revealing where points of exploitation occur, and where sites of resistance are apparent. Alternatively, a sociology of the new configurations of health care can more effectively outline the changing responsibilities of healthcare providers and their capacity to enable or discourage certain behaviours use that operate around mHealth applications. Increasingly, as health and wellness are commodified through mHealth, social theory and empirical work can also reveal the role of particular groups, individuals and communities in resisting such process, or where they are complicit in supporting the system.

A key consideration in each of these areas is how users retain ownership and control of their data, which is a challenge that governments have yet truly to come to terms with, as it extends far beyond simple keeping of medical records. From the first round of the NHS Health App Library recommendations in 2013, research found that there were considerable gaps in the security features of data within these environments (Huckvale et al., 2015) Also alarming about this trend is how increased commercialisation of health data may generate more privatised solutions to health care, new health data monopolies, and less capacity for users to move freely between providers. In response, there is a need for healthcare providers to restrict such trends and, at the very least, address the possibility of developing a universal data export format for personal health data. This is no minor proposal, especially given the expansion of mHealth applications beyond conventional health environments – such as Spotify mood choices. However, it is an urgent imperative since there will be nearly no utility in the NHS defining approved mHealth apps, if all of the health data is locked into applications which are not on this list, or which do not identify themselves as mHealth environments. Indeed, the world's largest companies work more towards occupying space within the world's largest social media platforms, rather than consider building their own. As such, in order for mHealth to work, it will be necessary for government providers of health care to work within these large mobile application companies, which means entering into a struggle over the ownership and exploitation of the data accrued through such devices.

mHealth, Data Distribution and Theories of Surveillance

Whilst self-tracking relies on technologies used on the individual body, it also makes the body knowable to a range of institutions and organization. To this end, a further trajectory of research must explore how mHealth technologies are being used by specific organizations to monitor others. This work is clearly derived from but could also inform theories of surveillance. In part, this is because communal self-tracking forms the basis of the next steps in mHealth and risk prevention, where individuals are encouraged to share data online with other self-trackers – albeit within proprietary databanks. Indeed, looking to the future, it is apparent that many of these trends are finding their way more formally into corporations, organisations and the pedagogic practices of different institutions. For example, in the context of schooling, there is growing support for the use of "digital devices and software that allow students to collect, track, manipulate and share health-related data" (Gard, 2014, p.838) particularly within Health and Physical Education (HPE) (see Cummiskey, 2011). In his paper on what he describes as the rise of eHPE, Gard (2014) fuses physical education's focus on public health discourses with developments in digital technology. Elsewhere, Williamson (2015) argues that the growth of digital technologies designed to enable students to track and monitor their physical activity can be considered another dimension of governance within Physical Education. This represents a broader trend in which

schools are integrating data tracking and analytic technologies to monitor and measure student behaviours, a process described as the emergence of 'smart schools' (Williamson, 2014) or "sentient schools" (Lupton, 2014b).

Elsewhere, a number of authors are pointing to the corporate use of technology (Gilmore, 2015; Hernandez, 2014) to monitor the productivity and efficiency levels of their workers. Gilmore (2015: 3) example explores the 'complex ways wearable fitness technologies are transforming the concept of fitness at individual and institutional levels'. Till (2014, p.452) reveals how fitness technologies are being integrated as employee wellness programs, suggesting that "the data produced by devices, such as Fitbit, are conducive to existing techniques of corporate management in which workers are managed in terms of their quantified measures of productivity". Individuals are being encouraged to use these technologies by insurance and medical organisations, as a way of tracking their lifestyles/health activities (Hernandez, 2014).

In this sense, critical studies of mHealth provides an opportunity to explore the nuances of health surveillance. Commenting in a special issue on 'Health' surveillance: new modes of monitoring bodies, populations, and polities' French and Smith (2013, p.384) advocate the need for greater critical attention on ''health' surveillance, on its means and sometimes divergent ends'. If health data produced by self-monitoring circulates within health assemblages, then we need a better understand of how that data circulates and moves across different institutions. Critical mHealth studies are beginning to offer some insight. For example, Till (2014) suggests that the way in which health and commercial data are now used together reflects a 'syndromic surveillance' (Henning, 2004). Elsewhere, when examining the gap between the contexts for and practices with data, Gartland and Neff (2015, p.1467) focus on the 'social valences of data'. They identify six data valences (self-evidence, actionability, connection, transparency, "truthiness," and discovery) and explore how these come to be mediated and are distinct across different social domains. Similarly, Lupton (2014) provides important insights into the various modes of personal data production – private, pushed (encouraged), communal, imposed or exploited. Future research could begin to explore these modes of production within different social sites. Lupton (2014b) argues that "pushed self-tracking departs from the private self-tracking mode in that the initial incentive for engaging in self-tracking comes from another actor or agency".

We are yet to fully understand the impact of mHealth technologies on relationships which have, in recent years, been the focus of analysis of medical cyberspace and ehealth (Miah and Rich, 2008); doctor and patient, technology and bodies, patient and consumer. Furthermore, there has been an increase in the

number of commercial child-tracking devices and applications have been launched to allow parents to generate knowledge about their child's health, such as their physical activity (Williamson, 2015; Rich, book chapter?) In this context, there is also a pressing need to understand how mHealth is assembled with family relationalities. Such studies could involve a focus on the negotiation between different sites and values sets, such as the 'negotiation between commercial and community interests' (Barta and Neff, 2016). For Fiore-Gartland and Neff (2015, p.1469) "the renegotiation of these definitions occurs at the intersection of social domains and highlights the specific kinds of communication and mediation work that must be done around such data". Such research agendas would (re)position mHealth "ideologies and discourses that mobilise them beyond their transitory, ephemeral intervention in the lived environment" (Jethani, 2015, p.40).   Future research could also attend to the ways in which novel digital environments and different gatekeeping systems categorize and guide users towards particular mHealth technologies, for example, health organisations and commercial platforms.

Relatedly, it is useful to note that the taxonomy of health related aspects of mHealth experiences is porous. Thus, separating out specific interests and biomedical markers that are addressed through specific apps has become increasingly difficult, because of the complexity of defining health. Indeed, specifying these boundaries will become harder over time, as concerns of well-being are present within the underlying principles of social media and the sharing economy. For instance, through image recognition software, Google is working on technology that would be able to read the food content of an image and make a judgement about its calorific content (Parkinson, 2015). Again, one can easily imagine how such data could be utilized – or sold to – organizations that have an interest in understanding the eating habits of a population, and yet one would not typically think of photo sharing platforms like Instagram as mHealth applications.

In this regard, mHealth is part of a complex assemblage of institutions, bodies, and discourses through which differing meanings of health come to be constituted and sometimes resisted. We do not yet know enough about how different social groups negotiate and incorporate mhealth into everyday lives, nor specifically how moments of resistance to neoliberal systems of governance emerge, though some work has begun to explore such dimensions. For example, Barta and Neff (2016, p.528) identify the quantified self movement as a site for 'soft resistance' to big data practices "allowing the community to be aligned with commercial purposes at times and to the individual control and autonomy over data at others". Novel digital tools for sociological research enable researchers and understand conversations within communities orientated around mHealth using approaches such as social network analysis or discourse analysis. For example, Jethani (2015, p.39) argues that there is "creative and political energy within

practices of self-tracking" within the 'latencies' of the technological production of self-knowledge, for example the possibility of self-tracking communities forming coalitions with other crowdfunding communities or open source developers.

Social Inequalities, the Production of Knowledge and mHealth Policies

Concerns about these systems are not just pertinent to individual interests; there are critical concerns about the way in which app data is distributed within proprietary systems, which can have an impact on how healthcare provision takes place. Concerns about data ownership and exploitation is emerging as one of the most important issues facing the healthcare industry today, since an ability to harness data will dictate the limits of solutions in the future. For now, the direction of travel is to lock up increasing amounts of our health related data into proprietary systems, which limits the public utility they could generate, were such data actually publicly available. Below, we identify three key areas of ongoing and future research in relation to emerging questions about the social inequalities of mHealth.

Firstly, we need to understand the capacity for governmentalities (Rose, 2000) through which the collation of big data on particular groups/populations may come to have significant implications. This connects with some of the enduring questions of social control within and through medicine, which have long occupied the work of sociologists of health and illness (Zola, 1972). Relatedly, there are ethical questions about the utilization of this data in the development of particular health promotion programmes, interventions, or funding plans, which may even further exacerbate social inequities. For example, the potential for algorithms and monitoring systems to identify relationships between beahviours and particular individuals and groups raises questions about the way in which this big data is used as 'evidence' in the stigmatization of social groups. Theoretical accounts of governmentality and mHealth as biopolitics could examine how mHealth is utilized to identify how particular populations are deviating from the norm and the use of this data to develop health policies, programmes and targeted interventions.

Secondly, it is also necessary to ask how this data is being used in the context of 'expert knowledge' to produce new risks associated with particular populations. The production of knowledge about and on people's bodies through quantified norms, can be considered to be part of a 'biopolitics' of populations (Foucault, 1990) through which particular subjects are normalized and moralized. For example, in 2013, a report by think-tank Demos gathered media attention in the UK after it advised that 'people who lead healthy lifestyles should be rewarded with easier access to healthcare. The report explores the impact of

having a more 'responsible' population, and is largely focused on public health (NHS, 2013). It gives some indication of the potential for such data to exclude those who not conform to or who are unable to meet the expectations of health imperatives.

Thirdly, whilst mHealth is celebrated for its ubiquitous potential, it is necessary also to be vigilant of the populations that are still absent from these environments and the inequalities and disparities (Castells et al 2007) this might exacerbate, as mHealth increasingly becomes a driver of health care. One may also learn from the debates about what Livingstone and Helsper (2007) describe as 'a continuum of digital inclusion', particularly in the sense that, while access to mobile health is growing, it is necessary also to be vigilant of the populations that are still absent from these environments and how that population may change over time. As such, empirical studies are needed which explore how different geographical, familial socioeconomic, spatial, and cultural factors shape, limit or provide opportunity for the use of mHealth technologies. The neoliberal orientation of many mHealth technologies, overlooks the complexity of health and the interrelationships that come to constitute health and within which health practices and choices are made possible (Mol, 2008). The increasing use of global positioning systems (GPS) in apps and wearable technologies speak both to the spatialities of mHealth and also some of the longstanding debates about the nature of the relationship between online and offline contexts.

Whilst there is evidence that populations are much more inclined to use technology to monitor their health, rather less attention has been paid to understanding how different geographical, familial socioeconomic, spatial, and cultural factors shape, limit or provide opportunity for particular kinds of use of mHealth technologies and digital practices. The developments in GPS, gamification and wearable technologies demand conceptual approaches that avoid sharp demarcations between seemingly online/digital and offline/physical worlds and moves towards a non-dualist understanding of digital health practices. This compels us instead to think critically about spatiality and decisions about when, where, how and why we reach to mHealth in our everyday practices. Multi-source data collection, spatial-time maps and other novel methods may become increasingly important in understanding complex everyday digital health practices in *real time*, space and place. Critical perspectives of this kind can help identify nuanced inequalities and disparities of mHealth across different socio-cultural groups, shedding light on variations in terms of mHealth literacy (Meppelink, van Weert, Haven, & Smit, 2015)

Conclusion: Towards to the Long Tail of Commercial mHealth

The sociology of health has begun to contribute to a critical reading of emerging mHealth technologies. Throughout this paper we have explored these insights whilst also signalling theoretical directions for future work in this field. The range of theoretical perspectives explored mean there is no single, comprehensive view of the body and mHealth, and each approach provokes different questions of materiality, representation and identity. Whilst we have focused on studies of consumer mHealth technologies oriented towards lifestyle and targeted at the individual, it is important to note that these technologies are increasingly being used within organisations and institutions for the purposes of monitoring others. In some ways, this has signalled a collapse of the ostensible boundaries between medical technologies which have a therapeutic focus (addressing medical conditions), and commercial mHealth technologies focused on the pursuit of self-enhancement. Indeed this neat separation quickly disappears when we consider for example a GP referring patients to lifestyle-based apps to monitor their physical activity patterns.

It is tempting to encourage future research to focus solely on the established mobile media culture that is flourishing around health care today. However, present day mobile devices must be seen as intermediary mechanisms, mostly ill-equipped to carry out the efficiencies sought by its advocates. The next stage in the evolution of migratory data patterns is in the rise of wearable health technologies (wHealth) and their being enabled by the growth of the internet of things and a wider participatory culture of invention and discovery. Notwithstanding the capacity of the largest digital media organizations to acquire most of the outstanding propositions from new, start-up mHealth companies, one of the key consequences of this could be the further fragmentation of health data, but also its exponential growth in volume.

In 2004, Anderson conceived the notion of the 'long tail' (2004), which describes the new economy of digital culture, where the larger volume of low users exceeds the high peak of fewer users. In a similar vein, one may talk about the long tail of health care reform being dependent on the optimization and exploitation of data. Such trends may signal a need to consider the connections between digital technologies and broader biomedical spheres. Yet, for all of the discourse around the need for open data initiatives, the mHealth industry is progressively undermining this prospect year after year, leaving health care providers and governors increasingly less able to meet the demands on their system. We have sought to explore the underpinning trajectory of such trends, considering new forms of self-tracking technology are situated within wider technological processes. The rise of the internet of things, the growth of citizen science, new implant technology, and the emergence of DIY gene editing kits are examples of trends within this field. Together, these artefacts of our technological culture speak to a future for self-tracking in healthcare, which is becoming increasingly automated and increasingly invasive, the utilization of

which may eventually frustrate the underpinning ethics of health care provision or at the very least, ensure the economic and political position of digital corporations, as holders of the intellectual property which hosts our data.

On this understanding, there are many other aspects of mHealth that require further consideration as one looks towards the early stages of these future trends.   The speed at which technologies are developing raises questions about the adequacy of theoretical frameworks and method. For example, Jethani (2015, p.36) asserts that the emergence of wearable technologies and biosensors have oriented the focus about how "how sensors are being projected inwards into the body' in ways that 'reorients the study of self-tracking practices as new media". Ultimately, the end point of digital health solutions may be a complete erosion of autonomy in a world where this control is assumed by intelligent machines, capable of providing the appropriate response to undesirable fluctuations in our health status. Whether or not we would be better off as a population for handing over such control to autonomous systems remains to be seen, but it is crucial to recognise that such a system would be underpinned by a very different set of assumptions about what constitutes autonomy or free will. At the very least, wHealth describes a completely novel set of interfaces between the user and the self-tracking technology, which characterises a new field of investigation into how technology is changing health care.

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