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Rethinking agency and medical adherence technology: applying Actor Network Theory to the case study of Digital Pills

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Abstract

Much literature surrounding medical technology and adherence posits that technology is a mechanism for social control. This assumes that the medical establishment can take away patients' agency. Although power relationships and social control can play a key role, medical technology can also serve as an agentive tool to be utilized. We (1) offer the alternative framework of Actor Network Theory to view medical technology, (2) discuss the literature on medication adherence and technology, (3) delve into the ramifications of looking at adherence as a network and (4) use Digital Pills as a case study of dispersed agency.

Keywords

Actor Network Theory; agency; Digital Pills; medical adherence; medical technology

Medication adherence is a major public health problem (Bosworth 2012a,b). Failing to take medication as prescribed can result in poor health outcomes, increased mortality and healthcare costs (Bosworth 2012a,b) and can also invalidate the results of clinical trials (Farmer 1999). Thus, limited adherence constitutes a significant public health problem with major health, research and economic impacts. We define adherence as 'the extent to which a person's behavior … corresponds with agreed medications from a healthcare provider' (World Health Organization 2003, 17). Adhering to the medications is crucial yet difficult to maintain. Only 50% of chronically ill patients adhere to their medications (Sabaté 2003). Identified factors related to low medication adherence include medical illiteracy, forgetfulness, low selfefficacy, side effects, poor doctor–patient communication and lack of social support (Kucukarslan 2012; Murphy et al. 2012; Stegemann et al. 2012).

As chronic illnesses become more prevalent, there is a need for patients, doctors and care-givers to be involved in the management of long-term medication regimens (Johnson and Shalansky 2007). Recommendations to achieve these goals include using technologies to improve communication between doctors, nurses and patients within a new patient-centered

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medical framework (Institute of Medicine 2001). Such a framework is moving toward individualized medicine that relies on patient empowerment and improved communication between the healthcare network stakeholders (Reid et al. 2005). For example, a systematic literature review suggests that nurses' patient-centered communication style can improve patients' adherence to the treatment plan (Charlton et al. 2008). However, little is known about the potential impact of communication technologies to enhance adherence and communication within the healthcare network.

The innovation called 'the digital health feedback system' or 'Digital Pills' (DPs) developed by Proteus Biomedical Inc. constitutes an example of a communications device designed to improve medication tracking and adherence. The DP is an ingestible sensor that detects medication intake and physiological data. This information is transmitted to devices of doctors, nurses, family members, or others in the patient's network. Patients who choose to use this device would also be able to fully control what information can be shared and with whom (Proteus Digital Health 2012).

Despite the potential of such communication devices, the medical system has been slow to adopt them (Topol 2012). We propose that the reason lies in the way technology in medicine is viewed. This article's aim was to unpack the DP technology to understand the technical aspects and their social implications. Setting the frame for understanding the DP within the medical system, we critically review previous methods of adherence measurement, different perspectives on medical technology, the technological aspects of the DP and their potential impact on adherence.

By exploring the DP in this way, we argue that technology in health-care can be conceptualized using other paradigms *in addition* to the commonly held Foucauldian one, which many scholars use as a lens through which to perceive technology as a social control mechanism. This specific literature regarding medical technologies contextualizes agency in top-down hierarchical power structures or implies that technology can take away agency, or the patient's autonomy and independent capacity to act (Latour 2011). However, medical technology can also be conceived as a tool to be utilized within a network that is comprised of the technological and the social. In arguing so, we introduce the concept of *dispersed agency*. This is the idea that control and overall ability to be an actant, which means possessing the ability to play an *active* role, is encompassed by multiple entities in a social network – whether those entities are human, technology, or concept (Law 1992; Prout 1996; Latour 1999; Castells 2004; Crawford 2004; Valente 2012). We propose to rethink agency in the context of technology and society, examining DPs as a case study from the framework of Actor Network Theory (ANT).

OVERVIEW OF THE CONCEPT OF MEDICAL ADHERENCE AND TRACKING SYSTEMS

The concept of adherence is highly contested and has changed over the last 40 years to reflect a switch from a doctor-centered to a patient-centered framework (Bissonnette 2008). The term compliance was mostly used in the 1970s and 1980s, but the World Health Organization called for a switch to 'adherence,' as compliance had evaluative and

paternalistic connotations of a passive patient that blindly follows doctor's instructions. The patient was the one to be blamed for non-compliance, while the term adherence was meant to reflect patient's agreement with the treatment. More recently, the term 'concordance' was introduced as an alternative to adherence to further highlight the active role of patients and the need for providers to develop a partnership with them to achieve mutually agreed treatment goals (Bissonnette 2008). Accordingly, in the 1970s, research on adherence focused on individual patient characteristics (e.g. personality) and then expanded to focus on social determinants such as socioeconomic barriers (Lutfey 2005). Lutfey (2005), for example, argues for the need to examine adherence at the interactional level and focus on doctor–patient communication.

In relation to the medication adherence tracking, accurately measuring adherence behaviors is challenging (Farmer 1999; Johnson and Shalansky 2007), as patients and doctors tend to overestimate medication adherence (Stephenson et al. 1993; Koehler and Maibach 2001; Font et al. 2012) and self-report measures are usually inaccurate (Lloyd et al. 2009; Harbig, Barat and Damsgaard 2012). Thus, medical technologies have been developed to improve adherence measurement and outcomes.

There is a trend in the history of medication adherence tracking technology toward developing strategies and devices that are less reliant on patients' self-reporting in an effort to reduce patients' unconscious (e.g., as they can forget) or conscious misreporting of adherence. Indirect measures such as reviewing pharmacy records or pill counting rely on patients' behavior (instead of self-report), but this system can become inconsistent and unreliable if patients receive medication at different pharmacies. Medication refill or pill counting also does not necessarily translate to actual medication intake (Farmer 1999; Shi et al. 2010) because some patients hide their untaken doses or forget to bring them to the appointment (Stegemann et al. 2012). Direct measures of adherence include observation of medication intake, with the risk that patients can fake swallow. Another method is detecting the drug in bodily fluids, which, however, cannot discern whether patients have only taken the medication right before the appointment. Thus, such methods neither assess information about medication intake between visits nor do they adequately capture or describe reasons for discontinuation (DiMatteo 2004).

In the 1980s, electronic medical devices were developed to improve adherence tracking to overcome these shortcomings (Farmer 1999). For example, the medication event monitoring system detects every time a pill bottle is opened and/or when a pill is extracted from it. This method proved to be more precise in capturing patterns of consumption and less reliant on patients' memories, but tracking the behavior of merely opening a bottle cannot directly measure *actual* medication consumption. Indeed, studies with pill dispensers show that as the medical appointment approaches, some patients click numerous times to 'fake' adherence (Farmer 1999; Arnet, Walter and Hersberger 2013).

Other examples of such devices include the following: the Intelligent Drug Administration System, which reminds patients to take medication; a programmable technology that operates through press-through-packaged medication tablets; the Smart Blister, which utilizes radio frequency identification; and the list goes on to include several special

watches, pill dispensers and smartphone applications (Koehler and Maibach 2001; Figge 2011; Van Onzenoort et al. 2012).

The DP is a novel electronic device that was approved by the United States Food and Drug Administration (FDA) in 2012 (US Food and Drug Administration 2012). The DP consists of a 1-mm ingestible sensor made from edible ingredients that can be attached to any pill. Once the pill is ingested, the stomach fluids act like a battery and break down the pill to activate the sensor, which sends the medicine ingestion date and time as well as other physiological information (heart rate, temperature, etc.) to a body-worn, disposable *patch*. Through bluetooth, the patch sends this information to a smartphone or computer. The data's receiver can include medical providers such as doctors, nurses, as well as relatives and friends. The software is designed to track adherence and alert when the medication is not taken. Mobile applications are also embedded to send reminders to take medication, or to notify family members so they may remind the patient (Proteus Digital Health 2012).

Thus, the DP overcomes some of the shortcomings of previous technologies by directly registering medication ingestion and includes communication tools that could potentially enhance adherence outcomes. However, medical technologies such as this are perceived very differently by the literature and by manufacturers.

THE LITERATURE ON MEDICAL TECHNOLOGY

Based on Jeremy Bentham's description of 18th century British prisons, Foucault (1977) refers to the panopticon as an optic effect based on the sinister architectural design that allows just one guard to surveil every inmate from a specific point while simultaneously preventing these inmates from seeing the watcher. This causes the inmates over time to internalize the feeling of being surveilled even if there is no one watching. The ultimate effect is self-surveillance and self-discipline. Some argue that in much the same way as this architectural innovation, systemic and institutionalized domination occurs today through the seamlessness of modern technology. Holmes (2001) argues that the metaphor of the panopticon is easily transferable to new medical technologies because they are used as 'an ideal vehicle for behavioral modification and for the correction and transformation of individuals, as well as training them, as desired by competent authorities' (Holmes 2001, 9). Medical technologies such as microphones, cameras and other audio-visual monitoring devices not only allow the gaze of the medical establishment on the patient to be domineering and unfairly unidirectional, but such instruments blur the line between care, discipline and surveillance:

> Whatever the official justification of these surveillance devices, whether for therapeutic order or for security reasons, the effects may be the same. Discipline and obedience may be paradoxical effects of this new surveillance technology
>
> (Holmes 2001, 9).

To take this theme of the disciplining nature of medical technology further, Michael and Michael (2010) conceptualize the term 'überveillance' to describe what they perceive as not just the pervasiveness and dangerous seamlessness of modern technology, but its ubiquity and institutionalization in the medical field especially. They posit that widely used

technologies such as mobile phones and laptops are ultimately surveillance devices because they can be used to track people and use their data in real time. However, it is their fear of medical technology, especially implantable microchips, that is the reason for their conceptualization of modern technology as a form of überveillance: 'Think of it as Big Brother on the inside looking out' (Michael and Michael 2010, 10).

The arguments in the medical technology literature continue as scholars warn that 'wireless networks are now commonplace … there is *nowhere* to hide in this digital society, and *nothing* remains private … the social implications of these überintrusive technologies will obey few limits and no political borders' (Michael and Michael 2010, 13). Furthermore, new mobile wireless computer technologies and social media applications using Web 2.0 platforms are deemed as tools of surveillance and persuasion by Lupton (2012). She argues that such technologies used in health-care create a digital cyborg body of the patient, allowing for the patient to be completely under the relentless gaze and control of the medical establishment.

This Foucauldian conceptualization of power is helpful in the context of medical technologies. In his later works such as in *The History of Sexuality* (1978), the French philosopher goes beyond the vertical, top-down characterization of power as per the panopticon, to a more nuanced view of power. Indeed, Foucault goes on to clarify his earlier pan-opticist conceptualization of power by outlining what 'power' is *not:* it is not

> a group of institutions and mechanisms that ensure the subservience of the citizens in a given state … [or] a mode of subjugation which … has the form of rule … [or] a general system of domination exerted by one group over another, a system whose effects through successive derivatives, pervade the entire social body … [one] must not assume that the sovereignty of the state, the form of the law, or the overall unity of domination are given at the outset
>
> (Foucault 1978, 93).

By defining power in terms of its exercise, Foucault readily attaches the notion of agency in a way that was only assumed in *Discipline and Punish*. Power as projected onto and internalized by the prisoner in the proverbial panopticon evolves into something that is exercised 'from innumerable points' including 'from below', that is, according to *This History of Sexuality*, linear and binary power does not exist; instead, power is the result of a network and interplay of relationships of resistance across society and encompasses the whole body politik (Foucault 1978, 96). Significantly, power is defined not by *whom* or *what* exerts it, but by its raison d'être and mechanism of furthering its purpose: 'to take life or let live' (Foucault 1978, 139) through 'the manifold relationships of force that take shape and come into play in the machinery' (Foucault 1978, 95) of knowledge creation. Although Foucault conducts an analysis of the history of sexuality in the West to exemplify this notion of power in its manifestation as 'the calculated management of life', the fundamental point he makes is that the anatomo-politics of the human body is a media of power (Foucault 1978, 139). Biopolitics, or the subjugation of bodies as a technique of controlling populations, thus comes to the foreground in Foucault's work as

a media of power. By characterizing this power as distributed, Foucault implicitly entails a characterization of agency as also distributed.

What Michael and Michael call a state of überveillance and where Lupton is concerned with wireless technologies in health-care, Gagnon and colleagues (2013) are concerned with what they term ‘technotherapeutics’, or the use of new medical data tracking devices such as microchips. All these devices essentially discipline chronically ill patients while intrusively surveilling the aggregate population of patients; thus, they call new medical devices that are able to affectively track patient data ‘anatomo-political’ and ‘biopolitical’ instruments of domination (Gagnon, Daniel and Guta 2013, 14). Gagnon and colleagues (2013) use Foucault’s conceptualization of power in the context of adherence as politics. By problematizing the management of the human immune-deficiency virus (HIV) infection, they describe how technotherapeutics is a way to ‘allow healthcare providers to identify those who “fail” to maintain an undetectable viral load because of poor treatment adherence … In this sense, technotherapeutics would not only reinforce surveillance but also create new opportunities for the management of people living with HIV’ (Gagnon et al. 2013, 67). Medical technology, as observed by Foucault and as reinforced by history may in the short term empower individuals, but they will ultimately serve to discipline bodies and regulate populations.

Such a view is extremely helpful in fleshing out issues of power (and the negotiation of power), questioning the motives and prerogatives of institutional use of health technology and by doing so bringing a critical light on the potential intrusiveness of medical technologies. Thus, the merits of the view held by the medical technology literature lies in its ability to demystify often complex (social entanglement of) technology in such a way that makes sense of its societal and political implications while describing and characterizing its utility the way technology throughout history and within institutional power relations has been, is being, and how it can be used by those in power. Conceptually, the Foucauldian view utilized by the literature on medical technologies is a powerful tool of the social analysis of technological artifacts – objects that are often taken for granted yet imbued with power as per their seamless role in the projection of power. In short, the analytical power of the Foucauldian point of view is that it systematically unpacks what is often easily, seamlessly hidden (e.g., Gagnon et al.’s technotherapeutics of HIV patients). What most literature on medical technologies has done thus far is adopt this view of health technology, to the critical benefit of consumers, manufacturers and academics.

Contrary to these arguments found in the literature on medical technologies, the DP manufacturers’ discourse is one of empowerment. Proteus uses the motto ‘powered by you’ to stress that patients decide who receives their information. Such a narrative emphasizes notions that go against losing agency such as taking control (e.g., ‘By capturing objective information and providing actionable insights, you can take control, communicate with care-givers and clinicians and stay well’) and independence (e.g., ‘Helius offers reassurance and promotes independence by keeping families connected’). Thus, Proteus presents DPs not only as a technology capable of directly tracking the ingestion of the pill, but also as a technology that can potentially improve adherence outcomes by enhancing social support and reducing access barriers (e.g., ‘We are committed to helping everyone – rich, poor, old,

young, near and far' and 'Our tools will allow people from all ages and cultures to power their own health').

However, are DPs either the panacea as described by the manufacturers or the oppressive value-laden technology as the medical technology literature suggests? The heart of this question's answer lies in the issue of agency. Some authors conceive agency as the capacity to act and decide freely (Latour 1992; Suchman 2009; Sayes 2014). According to the medical technology literature, technology reduces human agency by rendering the patient or individual as invasively and constantly surveilled and ultimately the target of politicized control. Whether through the panopticon of medical monitoring devices (Holmes 2001), of wireless überveillance (Michael and Michael 2010), of Lupton's (2012) digital cyborg, or of the biopolitics of Gagnon and colleagues' (2013) technotherapeutics, this view of technology as a value-laden agent begs questions of human volition and agency in the context of these power relations. In the medical technology literature, this view attributes change/effects primarily *to* technology (Hofmann 2002a,b).

On the opposing end, the view that technology is a panacea ignores issues of social control and power raised by the medical technology literature. For instance, the fact that sometimes patients consciously misreport or fake medication intake (Farmer 1999; Stegemann et al. 2012; Arnet et al. 2013) suggests that they may fear being judged and may feel more comfortable pretending they are following the doctors' recommendations rather than communicating their challenges taking the medication or expressing their decisions not to take the medication. Therefore, despite the changes in terminology, adherence issues can entail a power imbalance between doctors and patients. Hence, in the context of technology and medicine, a theory that takes into account other possible actors in the discourse about medical adherence merits attention.

ACTOR NETWORK THEORY

Actor Network Theory is a conceptual framework that views agency as dispersed because its topic of analysis and variable of measurement is networks (Crawford 2004; Valente 2012). A network is the relationship between entities whose power, and therefore agency, is measured by and depends on the network itself (Law 1992; Latour 2011). Actor Network Theory attributes agency regardless of whether the entity is material, abstract, or human as long as the entity is relational to other entities in some way (Crawford 2004; Latour 2011). As such, the only prerequisite of encompassing agency is being part of a network (Sayes 2014). Because agency according to ANT is dispersed, networked and instilled in non-human actors, agency is attributed based on the broadest standard: an actor has agency as long as it (1) makes a difference in the course of some other agent's action and (2) this difference is detectable (Sayes 2014). Agency is the means to 'act as a gathering, with other actors' and most importantly, *because* of other actors (Sayes 2014, 141). Ergo, what gives analytic leverage to the perspective of ANT is its supposition that social phenomena cannot be reduced to being solely human but must always be considered entangled with the material/technological.

Exemplifying this is Goodwin (2009) application of ANT on an observation of surgical patients undergoing anesthetic processes. Anesthesia involves the progressive loss of the patient's capacity to sustain his/her own life support. The anesthesiologist's technical expertise and professional judgement make anesthesia possible (Suchman 2009). This, *along with* the technical apparatus, provides a supply of specially mixed gases that induce anesthesia, without which surgery would be impossible. In lieu of the patient's own agency over his/her life, agency is dispersed throughout the network of machines, medical practitioners and protocol (Goodwin 2009). How Foucault (1978) conceptualizes power as part of a cluster and network of resistances, Goodwin conceptualizes agency as lying in these sociotechnical arrangements that comprise a network.

Despite ANT's insight into agency and the issues with technological determinism, it is not to say that ANT's arguments are unproblematic. The theoretical issues with ANT have to do with its vast definitions and seemingly universal applicability. If agency is dispersed in the manner that ANT conceptualizes, that is by extending agency to the conceptual, and abstract as well as to the material, where does agency *not* lie? If an entity is to be defined in accordance to ANT, with all of its networked components taken into account, where exactly does the network end and why? Furthermore, what is the threshold for how much salient difference an agent has when defining its detectable effect on another agent? While such criticisms have significant implications in the way ANT can be used as a theoretical lens, they do not hamper the insights and plethora of questions that medical technologies beg. What ANT does is suggest other ways to view and discuss technology's involvement in sickness and healing (Prout 1996) in such a way that deconstructs commonly held views. Despite these possible limitations, ANT still offers a different way of discussing and exploring the same subject of past inquiries regarding technology and society. While the literature on medical technology limits the scope of inquiry to how 'intrusive' technology (by default) affects people (mostly as a mode of control) and manufacturers leave several assumptions unquestioned, ANT allows for a different line of inquiry: how are social functions being performed within a complex network of diverse actors? Where the Foucauldian view focuses on power, ANT focuses on agency. Therefore, the way in which agency is distributed and negotiated between the actors in the network should be explored. To delve into this idea of dispersed agency posited by ANT, we use the case study of the DP and medical adherence to show how ANT provides a useful framework to view technology.

MEDICAL ADHERENCE AND DIGITAL PILLS FROM AN ACTOR NETWORK THEORY PERSPECTIVE

From an ANT perspective, adherence should be analyzed at an interactional level by examining how adherence behaviors are constructed: 'adherence is not a predetermined characteristic of individual patients, but a product of the networks in which those patients function' (Lutfey 2005, 424). Lutfey (2005) conducted an ethnographic study in two different settings about adherence from an ANT perspective by observing medical visits and interviewing providers about adherence. She found that providers engaged in different roles to negotiate patient adherence (e.g., as educator, policeman, detective). While doctors

tended not to use authoritative claims, they were still trying to convince patients to adhere to the treatment (‘old goals, new ways’). Providers with different degrees of expertise tended to use different strategies as less experienced physicians enacted the policeman role to a greater extent than more established ones. The ecological environment also played a role. Thus, this type of study from an ANT perspective does not locate adherence as an individual behavior nor makes assumptions about power, but analyzes how adherence is negotiated and constructed. Adherence is not conceptualized as solely a patient’s individual behavior, but as a result of a network of patients, nurses, pills, cellphones, medical research, etc. (Law 1992; Crawford 2004; Latour 2011; Valente 2012; Sayes 2014). The DP contextualized in this network of medical adherence is not independent or mutually exclusive but instead is a vital entity. It is not just a technical artifact but also a cultural and contextual one as defined by its network.

Although some medical technology scholars tend to think about medical devices like DPs as social control mechanisms (cf. Michael and Michael 2010; Gagnon et al. 2013), we can contextualize technological devices within a network of actors that negotiate the meaning and role of medical technology if we use ANT. The medical technology literature perceives medical technologies as the materialization of Foucault’s panopticon or biopolitics because patients are under constant surveillance or the target of control (cf. Holmes 2001; Lupton 2012; Gagnon et al. 2013). Although power can play an important role in the context of doctor–patient relationships, it may be problematic to readily assume that technology is always used as a social control mechanism imposed upon disempowered patients. Technology can be both constraining and enabling depending on the specific context of use and it is necessary to conduct empirical studies to examine how users perceive the technology rather than making deterministic assumptions about the power of technology to control (Essén 2008). For instance, Essén (2008) conducted a study with elders that use an e-surveillance system that monitored their activity patterns (e.g., sleep) and sends that information to caretakers so that they could be alerted in case the activity is not normal and may signal potential problems. Most of the elders had a positive view of this technology. Rather than perceiving it as a mechanism of social control, they felt that this technology allowed them to feel more secure, cared for and freer because they could remain at home instead of living at a nursing home. Only one elder in the sample expressed ‘big brother’ privacy concerns and noticed how she was starting to be aware of or modifying her behavior due to the fact that she was being observed (similar to the notion of self-discipline) and decided to discontinue using the e-surveillance system (Essén 2008). Empirical studies like this show that some of Foucault’s concepts that are applied in the medical technology literature are applicable, but patients can feel empowered and more autonomous with technology as well.

On the other hand, Proteus does not take into account power issues and readily assumes that a better connectivity between patients, providers and family members inherently will result in enhanced support. Nevertheless, giving access to the patient’s medication intake record may result in conflict and power negotiation, especially if the patient is non-adherent or prefers to retain sole control of his/her medication information. Although the idea behind DPs according to Proteus is to improve access for patients from all socioeconomic and cultural backgrounds (Proteus Digital Health 2012), it is still unclear whether costs may

hinder low-income patients' capability to use DPs. Furthermore, based on historical and contemporary experiences with the medical system, many ethnic minorities have higher levels of medical mistrust compared with whites (LaVeist, Nickerson and Bowie 2000; Northington Gamble and Wynia 2006). This may in part impact their perceptions and willingness to use DPs. Additionally, Proteus targets DPs to combat patients' 'forgetful impulses,' but certain medications are discontinued due to burdensome side effects instead or lack of belief in the efficacy of the medications (Martin et al. 2005; Bickell et al. 2006; Simoni, Frick and Huang 2006; Kahn et al. 2007; Huiart et al. 2012). Ergo, from an ANT perspective, we cannot assume that either the DP would just function as social control mechanisms as the medical technology literature posits or that DP will readily result in increased social support as is claimed by Proteus. We need to conduct empirical studies that explore how DPs work in the social context of patients from different socioeconomic and ethnic backgrounds and with different types of diseases.

From an ANT perspective, using technology does not necessarily result in the clear-cut loss of agency or in outright empowerment. When agency is conceptualized as the capacity to make a difference on other actors' actions (Sayes 2014), patient agency in adhering to medication is not eliminated but dispersed within the human and non-human actors that comprise the patient's network and it becomes an object of study per se. This network may include medical staff and medical devices, as we saw in our previous example with anesthesia. Medication intake would depend on various interrelated actors. The patient is the one who takes (or not) the medication and decides with whom to share the information, which may also depend in part by the patient's sociocultural context. The technical devices including the sensor, the patch and the applications are needed to capture, share and store adherence information. Therefore, the DP has agency insofar as it provides information-tracking/sharing. In turn, such information can impact the patient's medication intake awareness (and therefore prospectively the patient's behavior) and thus alter the interactions between patients, nurses and care-givers as they receive adherence information upon which to potentially act. Healthcare providers' responsibility would also include their judgement about when to consider a patient non-adherent (e.g., number of missed doses over a certain period), and they would also need to have the technical expertise to manage the DP applications (e.g., the Helius database). The medical system as a whole would need to incorporate a system of real-time information management. Thus, medication intake is no longer conceived as an individual behavior consisting of swallowing a medication, but as a behavior encompassed within a network of related human and non-human actors that impact each other within a certain social context.

FUTURE LINES OF RESEARCH

If we frame medical devices using ANT, the possibilities of utilizing technology are broadened and contextualized in such a way that allows us to see a useful place for them. ANT offers a conceptual framework for future inquiry into medical technologies that remain to be explored, especially as devices such as DPs have been recently approved by the FDA and only a few pilot studies have been conducted (Belknap et al. 2013; Eisenberger et al. 2013; Kane et al. 2013), and there are limited empirical studies that analyze user's perspectives of medical communication technologies (Essén 2008).

For instance, for some people, having one's relative reminding them to take medication may feel like a sign of caring and encouragement, whereas for others, it may be interpreted as intrusive and a violation of privacy. The interpretation may also depend on the type of relationship with the relative and the way the relative reminds or encourages the taking of medication. This type of interaction may be subject to conflict as well. For some patients, just knowing that their medication intake is being tracked and sent to others may increase awareness about medication intake and may change behavior. This again could either be welcomed or perceived as intrusive. The way in which doctors discuss medication intake data with patients (eliciting patient's challenges and preferences vs. judgement) could impact patients' perception of social support. Thus, similar to the case of the elders using e-surveillance, DP could be seen as a technology that enhances their care and support or it may be perceived as a social control mechanism that violates their privacy. From an ANT perspective, rather than assuming one or the other, it is necessary to explore the specific context and circumstances.

In the context of adherence though, can DPs enhance patient-centered communication around adherence? There is evidence that patients who are not asked about the difficulties of adhering to treatment are less likely to be adherent (Stricker et al. 2010). However, an observational linguistic study of patients with breast cancer, and their oncologist showed that discussions about hormonal therapy do not tend to address the challenges of adhering to the medication (Davidson, Vogel and Wickerham 2007). The use of DP may trigger discussion around adherence. Although this may not mean patient-centered communication per se, obtaining information about patients' medication intake could be a chance to elicit patients' challenges, values, goals and preferences related to medication intake, including the decisions about whether to use DPs or not, with whom in their informal social network (family, friends) and formal network (e.g., doctors, nurses) they would like to share their information and preferred reminder systems, etc.

Considering the resources to implement these studies will be important. The DP may seem to be a mere means by which people can be reminded to take medication on their own volition, in which the only agent is the individual utilizing the DP. The only existing network is the one that exists between the action of the person (consuming the DP) and the reaction of the artifact (DP battery activating via the person's stomach acids and eventually sending signals that help with adherence). This network, however, does not take into account what affects the DP and what the DP itself affects. Why may those that are chronically ill be willing to use a DP? Perhaps because of social norms set by living in a society where one has to take personal responsibility, or perhaps to compensate for a lack of social support that can act as a de facto reminder system, etc. If the individual is elderly and forgetful, then a reminder system is a significant factor in optimal medical adherence and thus optimal health. The DP is portrayed by its manufacturers as perpetuating this idea that people mean to be healthy yet cannot help but forget or even intentionally skip medication lest there is some social mechanism, spurred by the DP technology application, that promotes such behavior. Marketed assumptions such as these are therefore also involved. Perhaps even something as conceptual as one's culture and politics play a role – would a libertarian from rural America necessarily trust the DP enough to use it the way a Bay Area urbanite would? In turn, does the DP's agentive nature lie only in its *potential* to be part of a mechanism that affects

behavior only once an agentive patient decides to use it? Or does the DP's agency lie in the possible *capacity* of its effects once it is used? Opening up the DP using the concept of dispersed agency is therefore a quintessential example of how ANT begs many significant questions otherwise unasked. More importantly, such questions can only be explored if the network is given attention in such a way that encompasses the contextual. The DP should not just be seen as a technical artifact but a network of sociopolitical actors.

CONCLUSION

The development of the DP is a testament to the overwhelming polarity in the literature between the perception that the technology is a panacea (cf. Chu 2010), and those like the medical technology scholars that argue that any technology is imbued with invasive power (cf. Michael and Michael 2010). Actor Network Theory offers a powerful lens to explore emerging medical technologies to ask important questions regarding their social impact. That agency is dispersed within a network comprised of providers, relatives, patients, technology, etc. does not necessarily imply that patients lose agency. Dispersed agency may result in enhanced support and communications leading to better adherence and health outcomes, which may ultimately empower patients. Actor Network Theory empirical studies are needed to examine the ramifications of the DPs. This research can further inform interventions that can build on this innovative technology while accounting for the sociocultural context in which agency is negotiated across a network that includes both the social and the technological. Such efforts may ultimately improve medical adherence and health-related outcomes.

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