Article

Health Applications of Gerontechnology, Privacy, and Surveillance: A Scoping Review

Lisa F. Carver

Queen's University, Canada
4lfc@queensu.ca

Debra Mackinnon

University of Calgary, Canada
debra.mackinnon@ucalgary.ca

Abstract

In this era of technological advances designed to assist older adults to age in place and monitor health challenges, the emphasis has been on the surveillance of older adults for their safety and the peace of mind of caregivers. This article focuses on two emerging gerontechnologies: wearables and smart home or ambient assistive living (AAL) devices. In order to explore the intersections of the ageing enterprise and surveillance capitalism, this scoping review addresses the following questions: (1) what are the existing technologies; (2) what are the privacy concerns raised by participants, researchers, and caregivers due to intended and unintended uses of these technologies? Specifically, this article synthesizes twenty relevant sources concerning the surveillance potentials of these gerontechnologies and the privacy implications for adults aged sixty-five and over. While these technologies may offer older adults greater autonomy/safety and caregivers peace of mind, their surveillance and privacy infringement potentials cannot be overlooked or cast as a trade-off. Amidst the automation of the care, collection, combination, and commodification of various forms of personal, health, and wellness metadata, the right to privacy, dignity, and ageing in place must remain central to the adoption and use of these technologies.

Introduction

In an era of technological solutionism, industries, enterprises, and governments have begun amassing, aggregating, and analyzing data at an unprecedented rate (Malhotra, Kim, and Argarwal 2004). Based on its volume, velocity, and variety, big data and the array of technologies and infrastructures that enable it promise faster detection, prediction, and analysis. Lured by this explanatory and predictive power, big data hinges on weak purpose limitation as its power often comes from black-boxed algorithms and variegated *a posteriori* use (Constantiou and Kallinikos 2015). Positioned as “always-on” and “real-time” these technologies are predicated on monitoring or surveillance (Lyon 2007). However, more than just a technology, outcome, or autonomous process, big data surveillance is a new logic of accumulation—surveillance capitalism, “a new form of information capitalism [that] aims to predict and modify human behavior as a means to produce revenue and market control” (Zuboff 2015: 75).

So, as our bodies and surroundings become sources of information and commoditized, not only do we lose the ability to control our personal information and exercise self-determination (Smith, Milberg, and Burke 1996), but surveillance capitalism also serves to amplify vulnerabilities (Ball 2019; Lyon 2014). As Kenner (2008: 256) notes, “the structural inequalities and power asymmetries reproduced by the commodification and biomedicalization of ageing become quite visible when elderly care becomes an elderly crisis.”

A range of “gerontechnologies”—the combination of gerontology and technology—have emerged as technological solutions to this crisis. Part of the “aging enterprise” (Estes 1979), and echoing the rhetoric of preventative, personalized, and participatory medicine, these technologies seek to address and support motor

Carver, Lisa F., and Debra Mackinnon. 2020. Health Applications of Gerontechnology, Privacy, and Surveillance: A Scoping Review. *Surveillance & Society* 18(2): 216-230.

<https://ojs.library.queensu.ca/index.php/surveillance-and-society/index> | ISSN: 1477-7487

© The author(s), 2020 | Licensed to the Surveillance Studies Network under a [Creative Commons Attribution Non-Commercial No Derivatives license](https://creativecommons.org/licenses/by-nc-nd/4.0/)

and cognitive functions in older adults, defined here as those over sixty-five years old (Masterson Creber, Hickey, and Maurer 2016). Marketed as solutions to the ageing crisis, these devices promise greater health and wellness, personal safety, autonomy, and the ability to age in place. From wearables to smartphones and tablets, these technologies collect, combine, and analyze a variety of data. Where did you go? How far did you walk? What was your heart rate and was it regular? Did you have to stop and rest? Who did you call? What health appointments have you made? What health related products are you buying? What prescriptions are you filling? Armed with these data, these devices and platforms claim to provide users, caregivers, and practitioners with more reliable data to aid in detection and prevention.

Given that illness and disease become more common as we age, these devices provide the opportunity to detect the early warning signs before the disease impacts lifestyle or behaviour. The data collected by wearable assistive living technologies could be combined and analyzed to reveal medical issues (Carver 2018) of which the wearer or user is not yet aware (e.g., a cardio monitor whose data collection reveals evidence of a heart condition such as atrial fibrillation). While this data collection may promise peace of mind to caregivers or offer health care professionals greater insights, these technological fixes further normalize the surveillance of older adults and infringe on their rights to independence and self-determination (Minuk 2006; Percival and Hanson 2006). When juxtaposed against perceived threats to personal safety, surveillance is seen as necessary, caring, and even freeing (Essén 2008). However, reinforcing this false dichotomy between safety and surveillance serves to quickly dismiss rights to privacy and autonomy. In other words, while these devices and services have been shown to help overcome loneliness, relieve stress, and promote independence and self-efficacy (Leist 2013), the potential harms of data collection and misuse cannot be overlooked.

Older adults are one of the groups most vulnerable to the negative impacts of surveillance, and, given the increasing alignment of surveillance capitalism with the ageing enterprise, the tendency for these data to be combined and repurposed is not only probable but already commonplace in some realms (Richardson and Mackinnon 2018). For example, when combined, these data can be treated as a “health report”—a health-based credit report—used by insurers to assess the risks associated with applicants for travel health or other medical coverage (Carver 2018). Both are types of insurance often purchased by older adults. If the independent “health credit check” reveals atrial fibrillation or signs of dementia, it may result in discrimination by employers or insurance companies. The combination of traditional screening methods with new surveillance technologies leaves older adults vulnerable to exploitation and even the loss or termination of services (Carver 2018).

Therefore, like others calling for empiric and nuanced explorations of the potentials of big data and surveillance capitalism, we argue it is urgent that uses of big data, associated technologies, and the possible privacy challenges that they bring be explored before these usages become commonplace. Specifically, this scoping review examines the existing technology and known threats to privacy as documented in research with a variety of populations, identifying the risks to older adults’ privacy from intended and unintended uses of wearable and ambient assistive living (AAL) technologies.

We begin by reviewing relevant literature on “sensor-ed” older adults and surveillance-enabling technologies. Second, we offer a theoretical frame for understanding the alignment of surveillance capitalism and the ageing enterprise. Third, we detail the methods and results of our scoping review, highlighting key findings. As these surveillance technologies “vanish” (Murakami Wood 2014), we end with a discussion of new frontiers and reflect on the types of information created and collected as well as their implications.

Baby Boomers, Big Other, and Technology

Surveillance of older adults has been given little attention in academic circles (cf. Kenner 2008), yet digital, networked, and sensor-ed seniors may be the way of the future, especially among those sixty to seventy years old. Almost all Americans over sixty-five own cellphones (80%), and 42% own smartphones.

According to the Pew Internet and American Life Project, two-thirds of Americans over sixty-five go online, and, if we just consider the baby boomers, the vast majority (82%) go online (Anderson and Perrin 2017). However, these technological advancements may only further the “grey digital divide” and reaffirm ageism with respect to digital literacy (Morris 2007). A heterogeneous group, digital seniors, while no longer “sitting ducks” (Fox 2006), may still have limited agency in technological adoption due to their lack of knowledge and/or understanding of the underlying surveillance and targeted advertising compared to more “digital natives” (Baumann 2010; see Hargittai and Dobransky 2017; Quan-Haas, Martin, and Schreurs 2016). Since older adults tend to spend less time on the internet and social media than younger people, their lack of familiarity makes them the most vulnerable to online information insecurity, privacy, and fraud (Chakraborty, Vishik, and Rao 2013). Although older users may take fewer online risks than their younger counterparts, they are unlikely to engage in self-protective behaviours (Kezer et al. 2016; Miltgen and Peyrat-Guillard 2014).

Increasing attention has been paid to the privacy paradox facing young people today (see Moscardelli and Divine 2007; Livingstone 2008; Youn 2009); however, some of the same risks that face young people on the web exist for older adults. As stressed by Val Steeves (2008: 337), “The devices we use—our access cards, cell phones, and Internet connections—continually leak information about us into the ether, and that information is routinely collected unobtrusively by a number of third parties, including the state.” For example, health surveillance data in some cases is sent via wireless connection and transmitted to the web server via Bluetooth and is vulnerable to unauthorized access (Evangelista 2015; Mihailidis et al. 2008). Although baby boomers, having lived through the rise of privacy law, may place more faith in its oversight powers, many of these laws and statutes have become dated, as technological advances open doors to big brother and big other. In fact, big brother and conceptions of centralized control are no longer the pressing threat. Rather, in the information age, the aspirational appetite of “big other” to modify social relations and politics is a far more concerning (Zuboff 2015). Surveillance is big business and an extractive process where users are both the sources and targets (Lyon 2017; Zuboff 2015).

For example, the social networking sites that lure both young and old are designed to observe and report on every click and like, which are then sold to advertisers for targeted marketing. The information is provided by the consumers, through the sharing of photographs, personal information, and opinions (Schmarzo 2013). In most cases, big data will be used to guide a consumer to products and services, creating an ever more personalized advertising presence on the social media page (Constantiou and Kallinikos 2015). Recent announcements reveal that trackers hidden in apps such as Uber, Tinder, Skype, Twitter, Spotify, and Snapchat (O’Brien and Kwet 2017) are in use to target advertising, engage in behavioral analytics, and allow location data to be harvested by multiple companies without consent. Fundamentally, the collection of big data “renders individuals unable to observe, understand, participate in, or respond to information gathered or assumptions made about them” (Kerr and Earle 2013). And, as evinced by recent scandals, big data can also guide the user to a narrower set of options—for example, advertisements that reinforce attitudes already demonstrated through “likes” and following links. This is because “technical systems are typically designed by powerful actors to produce outcomes that address their interests, often at the expense of those who are less powerful” (boyd 2016: 231).

The most vulnerable older adults are often women and/or ethnic minorities of lower socioeconomic status, which is compounded by chronic disease and social isolation (Gellad et al. 2006; Glasse 1990; Hwang 2008). The abuse and exploitation of these older adults has been well documented in a variety of areas including housing and access to medical providers. However, the confluence of big data surveillance, surveillance capitalism, and the ageing enterprise perpetuates and extends existing privacy concerns, abuse, and exploitation.

Surveillance creep has long been a risk to older adults (Mortenson, Sixsmith, and Woolrych 2015). Closed-circuit television cameras (CCTV), sensor systems in chairs and doorways, tracking devices and apps, and physiological sensors have become commonplace in long-term care facilities (Minuk 2006; Mortenson, Sixsmith, and Woolrych 2015). Analogous consumer versions of these devices, such as ambient assistive

living (AAL), smart home, telecare, and smart interface technologies are also becoming more popular in private homes (Mortenson, Sixsmith, and Woolrych 2015). AAL includes “information and communication technology (ICT), standalone assistive devices, and smart home technologies in a person’s daily living and working environment [that work] to enable individuals to stay active longer, remain socially connected, and live independently in old age” (Blackman et al. 2016). In addition to AAL, there are a range of mobile health apps (Office of the Privacy Commissioner of Canada 2014) and wearables. These include smart watches, body sensors (e.g., heart attack and stroke detectors), body cameras, smart clothing (e.g., insoles for balance), implantables (e.g., contact lenses to help diabetics monitor their blood sugar levels), and other specialty devices (e.g., digital stethoscopes and assistive cutlery for Parkinson’s). Although designed to support ageing in place, these technologies compromise privacy in real-time, as well as contribute to data collection that can be utilized in technology that has yet to be developed.

Updating Ageing in Place, with Dignity, and the Right to Privacy

The Centers for Disease Control and Prevention (2009) define ageing in place as “the ability to live in one’s own home and community safely, independently and comfortably, regardless of age, income or ability level.” We stress the importance of combining progressive understandings of older adults with broader discussions of ageing with dignity and the right to privacy. While a strong case for the adoption of gerontechnologies can be made in exceptional circumstances, such as in light of care and concern with health and safety (e.g., the monitoring of an older adult with advancing Alzheimer’s), the mass ratchetting of these surveillant technologies for older adults normalizes monitoring. In many cases, this intrusive solutionism results in surveillance becoming a precondition for autonomy, reinforcing the familiar trade-offs between privacy and safety.

Mortenson, Sixsmith, and Woolrych (2015: 518) highlight the relationship between surveillance and oversight, drawing connections between Foucauldian understandings of power, governmentality, and surveillance and Goffmanian ideas of total institutions and dramaturgical analysis. Power over older adults can be considered a protective function, a way of reaching out the long arm of paternalism to protect vulnerable older adults from their own weaknesses (illness). Power, in this context is rooted in the social structures, not distinct from them (Foucault 1980). It is wielded, in part, to ensure that older adults are unable to harm themselves through poor decisions or unhealthy behaviours (Mortenson, Sixsmith, and Woolrych 2015). To avoid or delay the need for long-term care facilitates and total institutions (Goffman 1961), technologies are positioned as another means of watching over older adults.

This research project is contextualized socio-functionally within a technical discourse that examines the functional and non-functional elements of surveillance technology and big data collection, and within a privacy discourse, which is concerned with the balance between an individual’s right to privacy and the positive and protective benefits of the surveillance of older adults (Courtney et al. 2008; Steele et al. 2009). Mortensen et al. (2015) explain that functional factors incorporate user requirements (e.g., ease of interface and usability) and the ability to meet needs/solve problems. The privacy discourse is situated within the technical discourse and reflects the advantages of the technology (the service it provides) and the violations of privacy it requires (personal data recorded). For example, a wearable device that records and reports heart arrhythmia could be used to enable an older adult to make decisions about when it is safe to remain at the office or at home and when a trip to the hospital is warranted. However, it is more likely to be sent to an affiliated insurance company server and used in the calculation of a premium for travel or life insurance.

Better contextualizing this tension between constraint and care is critical in the creation and adoption of emerging technologies, especially for and by older adults. However, as argued below, rather than a trade-off, we contend that efforts to age in place and with dignity are congruent with a commitment to privacy. While we are critical of the forms of protectionism and paternalism faced by older adults, more attention needs to be paid to the alignment of the ageing enterprise and surveillance capitalism. In other words, can this ethic of care extend to and protect against the threats of big other?

Methods

This review updates and extends existing studies of technology and identified privacy threats to various populations, particularly the risks to older adults' privacy from intended and novel uses of popular gerontechnologies. We followed the five stages of Arksey and O'Malley's (2005) framework for scoping reviews: (1) identifying the research question, (2) identifying the relevant studies, (3) study selection, (4) charting the data, and (5) collating, summarizing, and reporting the results.

This scoping review was guided by the following concomitant research questions: What are the existing technologies? And what are the privacy and/or surveillance concerns raised by participants, caregivers, and researchers due to intended or unintended uses of wearable and AAL technologies? We identified the relevant studies by reviewing health-related gerontechnology literature published between 2007 and 2018 to gauge key concepts underpinning research and empiric findings. Specifically, we used subject headings, titles, and abstract keywords related to ambient assistive living, wearable technology, wearable devices, and/or monitoring systems, as well as keywords related to ageing, elderly, elder, older adult, or senior. Both Summon Service and Ovid MEDLINE databases were used to capture social science, medical, and health related research. Additionally, we repeated the search in EMBASE and Sociological Abstracts. All titles and abstracts from the search strategy were reviewed for eligibility. Reference lists were also examined for relevant articles. It is important to note that, as Arksey and O'Malley (2005: 24) themselves acknowledge, limits must be placed on both the date range and number of databases searched for practical reasons, and reviews may potentially miss relevant papers. Articles were excluded that did not describe the data collected, provided no information on the uses of the technology, were about other technology (e.g., hearing aids or Cochlear Implants), involved condition-specific technology (e.g., cardiac monitors) or specific patient populations (e.g., inpatients), were not available in full-text, or were not in English.

Results

As depicted in Figure 1, in stage two and three of the scoping review—identifying relevant studies and study selection—our search retrieved 582 records. We screened the titles and abstracts for duplication and to select the articles for full review. Thirty articles were removed due to duplication. The majority of articles (497) were excluded after a screening of their titles and abstracts, primarily due to content related to other technologies (e.g., hearing aids). Seven additional articles were identified through the reference review process. In total, fifty-seven articles were identified for full review. The full-texts of these articles were independently reviewed by both authors for the inclusion and exclusion criteria. Twenty studies that researched older adults and wearable or ambient assistive living technology were included in the final analysis. Stage four of the scoping review—charting the data—is demonstrated in the analysis given in the results section as well as shown in Figures 1 and 2, and in Table 1.

Stage five of the scoping review—collating, summarizing, and reporting the results—is reported here. The majority of articles were concerned with two distinct types of monitoring equipment: AAL/smart home monitoring equipment ($n = 10$) and wearable devices such as fitness trackers ($n = 6$) and a smart fabric ($n = 1$) (see Figure 2). In addition to these emerging technologies, three of the articles focused on everyday technologies (e.g., internet banking, ticket vending machines, and kiosks) ($n = 1$) or smartphones and tablets ($n = 2$).

Figure 1: Scoping Review Chart

Although there were a variety of gerontechnologies studied in the papers included in this scoping review, the most popular were the AAL/smart home monitoring equipment systems. Smart home monitoring and AAL devices are a subset of Internet of Things (IoT) enabled technologies, which network home devices through cloud platforms in order to provide real-time feedback to users, manufactures, and third parties (Gram-Hanssen and Darby 2018; Hargreaves and Wilson 2017; Strengers et al. 2016 cited in Maalsen and Sadowski 2019). With many general smart home devices on the market, AAL home monitoring systems, in this context, refer to private spaces that have been fitted with sensors that are intended to record data that can be used by the monitoring caregiver or system to determine if the older adult being monitored is in need of assistance (Aloulou et al. 2013; Epstein et al. 2016; Evangelista et al. 2015; Kang et al. 2010). The monitoring devices can include sensors that detect when the refrigerator, medicine cabinet, or a door are opened or closed; if the stove is on; or if the water is running. They can also include a video recording system and mats that record activity in the bed, including respiration, heart rate, and movements. Similar to the intended uses of wearables, some smart home sensors are also used to detect movement around the home such as stumbling and/or falls (Pietrzak, Cotea, and Pullman 2014; Rantz et al. 2010).

These systems are considered cost effective for care providers, who might otherwise need to be with the older adult client twenty-four hours a day, and are “non-intrusive” (Epstein et al. 2016; Kang et al. 2010). The information gathered is evaluated by algorithms that are designed to alert caregivers and/or family members if an alert is triggered (Berridge 2016; Caine et al. 2011; Evangelista 2015). Additionally, these systems require a database server and web portal to provide caregivers and family members with the ability to review the data (Rantz et al. 2010). Some older adults living with an AAL system express a sense of relief that the system has made their home safer for them (Epstein et al. 2016).

Figure 2: *Typology of Technologies included in Scoping Review*

Privacy concerns have been reported by “sensor-ed” older adult clients, by researchers, and by caregivers (Berridge 2016; Epstein et al. 2016; Pietrzak, Cotea, and Pullman 2014). With a fully installed AAL system there may be sensors in “private” areas of the home, including the bathroom and bedroom, as well as in areas such as the kitchen (Rantz et al. 2010). These surveillance devices collect data on the activities of older adults, including how much time they spend in the bathroom and what they do in there, as well as what they do in the bedroom (Berridge 2016). While many of these technologies are adopted for monitoring purposes, to many caregivers and family members, the weak purpose limitation or scope of the data collected appears to make the technologies more compelling. For example, “an incidental finding could lead to a useful intervention, or it could reveal an aspect of a resident’s life that she prefer be kept private” (Berridge 2016: 813). As one older adult explained, “if I had company or friends coming over, particularly a male friend, it might bother me... that I’m being monitored” (Berridge 2016: 814). The “personal life” of the older adult becomes known to their caregivers and even family members. Berridge (2016) reported on a surveillance alert that was triggered by an older adult spending “too long” in the bathroom. It turned out that the older adult “loved to take long bubble baths.... When it [the telecare center] called, she was upset because it made her get out of the bathtub” (Berridge 2016: 813). Older adults also cited issues such as the installation process, esthetic concerns, privacy issues, and social isolation (Berridge 2016; Kang et al. 2010).

Some caregivers embrace the idea of using AAL as a way to maintain control (Epstein et al. 2016) and/or as a tool to detect changes in physical condition (Berridge 2016; Mihailidis et al. 2008; Rantz et al. 2010), as well as critical events. Others felt uncomfortable with their role as watcher. As one social worker said: “I felt like I was invading their privacy” (Berridge 2016: 814).

Wearable devices were the second most common gerontechnologies found in the literature included in this review. Wearables are the human spoke in the Internet of Things and are defined as “a class of devices that incorporate electronics, software, and sensors on to, on top of, and around the body” (Richardson and Mackinnon 2018: 1). Wearables may include fitness trackers, smart watches, body sensors, smart glasses, body cameras, smart clothing and accessories, virtual reality headsets, and dosimeters (Richardson and Mackinnon 2018). Not limited to body-worn devices, wearables can also be attached to assistive technologies and mobility aids (e.g., wheelchairs) (Kang et al. 2010). These sensors and related software are used to monitor and measure actions, directly and indirectly across a range of environments (Richardson and Mackinnon 2018).

Since 2014, personal fitness trackers and smart watches have saturated the consumer realm, with many devices explicitly created or marketed to older adults. From the fall detection and emergency SOS features of the Apple watch to the sharable activity and caloric data with Fitbit to more specialized devices like Medical Guardian,¹ promotional material and various testimonials detail the benefits of these products to older adults. These, and analogous devices, record, infer, and monitor physical movement data (e.g., steps, sexual activity, falls), physiological data (e.g., respiration, heart rate, blood pressure), metadata (e.g., GPS location, time), and user-inputted data (e.g., calories ingested, workouts). Some have additional functions such as sleep trackers, a GPS locator/tracker, mobile payment, and notification for phone calls, email, and social media.

Although fitness trackers are often discussed as a group, “there are major differences between the devices and ... these devices may be using different measures of the behavior of interest” (Rosenberger et al. 2016: 462). For example, Rosenberger et al. (2016: 462) reported that the devices they studied had a tendency to over report sleep, and many devices did not accurately record moderate activity. They found the error in accuracy in reporting moderate activity important because of “the small percentage of time spent in MVPA [moderate-to-vigorous physical activity] in many populations, even modest measurement error is clinically significant in a 24-h period” (Rosenberger et al. 2016: 463). Given that “those most at risk for poor health outcomes were least likely to share fitness tracker data with providers” (Pevnick et al. 2016: 4), the use of wearable technology to collect these data without the active participation of the wearer is an eagerly anticipated application of wearable devices.

Table 1: Technologies included in Scoping Review

Wearables	Fitness Trackers	<ul style="list-style-type: none"> • Alley et al. 2016 • Chung et al. 2016 • Patel et al. 2017 • Pevnick et al. 2016 • Rosenberger et al. 2016 • Yang and Hsu 2010
	Smart Clothing	<ul style="list-style-type: none"> • Koh et al. 2016
Smartphone and Tablets		<ul style="list-style-type: none"> • Masterson Creber, Hickey, and Maurer 2016 • Patel et al. 2017
Everyday Technologies		<ul style="list-style-type: none"> • Hedman, Lindqvist, and Nygård 2016
Smart Home / AAL Monitoring		<ul style="list-style-type: none"> • Aloulou et al. 2013 • Berridge 2016 • Caine et al. 2011 • Epstein et al. 2016 • Evangelista et al. 2015 • Kang et al. 2010 • Mihailidis et al. 2008 • Peetoom et al 2015 • Pietrzak, Cotea, and Pullman 2014 • Rantz et al. 2010 • Rantz, et al. 2015

Clearly, the use of wearable devices to track and monitor older adults' behaviour, physiological states, and location have both helpful and harmful connotations. Knowing where an older adult is and what they are doing, as transmitted by GPS and/or the biofeedback applications, is a form of surveillance that allows

¹ See <https://www.medicalguardian.com/help-me-choose> [accessed June 7, 2020].

caregivers and family members to ensure that they are made aware of any change in health status. However, many older adults find the tracking aspect of smartphones to be a privacy invasion (Epstein et al. 2016). One older adult explained, “One reason I don’t have a cell phone is because I don’t want to be monitored ... people calling me up asking every minute of the day. That’s intrusive. You don’t want your privacy exposed” (Epstein et al. 2016: 46).

One of the reasons that wearable devices, such as fitness trackers, are of value in terms of monitoring the health of older adults is that they can automate the collection and transmission of personal health data without the wearer knowing precisely what is being recorded (Pevnick et al. 2016). In other words, older adults can be equipped with pre-programmed portable devices and the information gathered by these devices can be uploaded to monitoring systems without any involvement of the wearer. This automation of data transmission is of value to data users but presents another potential privacy risk to older adults who cannot give meaningful informed consent. Their information may be limited regardless of mental capacity due to the fact that they may not understand the extent of the information being collected, as well as the intended and unknown uses of these data.

Given the medical surveillance value of wearable devices, Rosenberger et al. (2016) recommend that validation of wearable devices needs to be done in a timely manner, especially in light of the frequent software and hardware changes that may result in new functionality. Consistent with broader discussions of technological innovation and emerging privacy concerns, these findings demonstrate the need for more meaningful consent, consent that recognizes the needs of older adults but also respects their right to dignity and privacy.

The remaining three articles focused either on everyday technologies (e.g., internet banking, ticket vending machines, kiosks) or smartphones and tablets. The article on everyday technologies was contextualized in the field of dementia research. Hedman, Lindqvist, and Nygård (2016: 4) found that users were concerned about trade-offs, including “integrity, safety, facilitating vs. training, impact of the technology on their spouses, and costs.” Their participants expressed ambivalence about the use of everyday technology to support them during cognitive decline and were concerned about it accentuating the loss of independence. Several chose to downsize (stop using technology) rather than live with the compromises it required.

With more features than typical consumer wearable devices, many smartphones (wearable in the sense that they are portable and usually carried on the person) are also capable of recording steps, exercise, sleep cycles and quality, caloric intake, calories burned, activity levels, and even social activity. These features are increasingly being used for fitness and health purposes as “smartphones also have the advantage of being able to extract data from multiple devices, direct user input, transmit data to a server, and facilitate a two-way communication between patients and providers” (Masterson Creber, Hickey, and Maurer 2016: 2). For example, many smartphones have accelerometers, which can detect falls, “record the location of the fall through the GPS feature, and aid in contacting emergency services” (Kang et al. 2010: 1581). Some caregivers have adopted the smartphone as a tracker in order to know where their loved one is at all times (Epstein et al. 2016: 43).

Masterson Creber, Hickey, and Maurer (2016) and Patel et al. (2017) looked at the use of smartphones to track older adults in various ways. Masterson Creber, Hickey, and Maurer (2016) were interested in the use of smartphones and tablets to prevent heart failure, improve care, and enhance the quality of life of heart patients. Barriers to utilization for their older adult participants included lack of user acceptance, cost, technology acceptance and competence, and the anticipated burden of using the device (including the manual upload of data). The technology was not easily used by those with poor health and/or low income and was considered a “resource intensive approach” (Masterson Creber, Hickey, and Maurer 2016: 6).

For Patel et al., the focus was on both smartphones and wearables as trackers of physical activity. The data that they accessed were provided by an insurance company and had been filtered through a wellness program. The activity app on the smartphone allowed the insurance company to know what the user was

doing at all times. Possibly because of the complete lack of privacy associated with the app, only 0.1% of participants over the age of sixty-five activated the app over a two-year period (as compared to 1.2% of those under sixty-five years old).

All of the gerontechnologies discussed here engage in health-related surveillance of older adults, falling into three main categories: stigma, loss of human contact, and loss of privacy (Epstein et al. 2016; Kang et al. 2010). Although some caregivers and family members may consider gerontechnology unobtrusive, for older adults there can be stigma attached to living with surveillance, especially in the most private aspects of their lives. They may “feel shame and view technology as an admission of dependence” (Kang et al. 2010: 1582). For some older adults and their caregivers, there is an attitude that AAL systems have value, but not for them (Epstein et al. 2016; Hedman, Lindqvist, and Nygård 2016). Many older adults recognize that requiring surveillance in order to remain “independent” is an oxymoron and express concern about their loss of autonomy (Epstein et al. 2016; Kang et al. 2010; Mihailidis et al. 2008).

Since these technologies are cast as tools of care, older adults were also concerned with the automation and potential decrease in care or social contact in addition to their concerns about privacy and a lack of familiarity with the technology (Epstein et al. 2016; Kang et al. 2010). Many older adults worry that family or friends who might have stopped in for a visit will no longer do so, reassured that their loved one is being watched over by a surveillance system (Kang et al. 2010). This loss of human contact can have serious consequences since social isolation is linked to poor health outcomes (Carver et al. 2018).

Loss of privacy and self-determination is also a concern for many older adults (Berridge 2016; Epstein et al. 2016; Kang et al. 2010; Peetoom et al. 2015). Berridge (2016: 811) reported that 98% of those offered an AAL system chose not to participate and 20% of those who tried the system discontinued their use, saying that they “felt it was intrusive and a threat to their privacy.” Additionally, those who did adopt the system often did so out of desperation, not because they were comfortable with the idea of being watched (Berridge 2016). For some older adults, the idea of AAL systems is acceptable in principle, but not in practice (Epstein et al. 2016). Epstein et al. (2016: 46) reported that many older adults “complained that being monitored was seen as threatening, intrusive, and, at times, insulting.” Another privacy issue is that many older adults do not realize the extent of observation (Caine et al. 2011), including “the tracking by hour of activity and designation of normal and non-normal ranges of activity” (Berridge 2016: 813). These participants knew that they were being observed but not the extent of the observation. For example, one said, “We’re not so stupid; we’re only old. We’re not stupid. This [monitoring] should not be. I read two papers a day, you know. I do not need monitoring” (Epstein et al. 2016: 46).

Although there is a developing body of research concerning the user adoption of AAL and wearable technology, the research looking at the efficacy of these surveillance methods in preventing harm and promoting independence is lagging (Peetoom et al. 2015; Pietrzak, Cotea, and Pullman 2014). For example, Pietrzak, Cotea, and Pullman (2014) point out that research has not yet shown whether AAL is effective in terms of falls prevention or early fall detection. And Peetoom et al. (2015: 291) express concern that “it is surprising that in a field where so many developments are taking place, only this little research is being done into the effects of these technologies in care practice.”

Discussion: New Frontiers

With saturation in the mass consumer market, many wearable companies have pivoted their technologies to workplace markets (Richardson and Mackinnon 2018). In particular, healthcare has been identified as a lucrative and growing area primed for further wearable adoption (Reitz, Blau, and McIntyre 2016). From measuring physiological and social responses to motion and displacement, these wearable and IoT companies are re-aligning the use-cases of trackers, sensors, and clothes to the ageing enterprise to “solve” issues of ageing.

While the physiological monitoring of older adults is commonplace, especially in terms of cardiac functioning, new sensor capabilities, as well as the combination of sensor data, have increased what can be inferred. Similarly, smart clothing and fabric-based gerontechnologies have made monitoring less obtrusive. For example, Koh et al. (2016) discuss an in-development microfluidic device that is sensitive to sweat and can measure biomarkers such as glucose, creatinine, lactate, chloride, and pH. Although primarily intended for monitoring diseases such as diabetes, the data combinations may have a range of diagnostic capabilities. And while traditional physiological monitoring devices must often comply with medical regulations, many consumer wearables have effectively navigated this legal grey area between health and wellness data.

In the US, all monitoring technologies used for diagnosis or treatment, including “off the shelf” devices, are considered by the American Food and Drug Administration as “medical devices” (Kang et al. 2010) and are controlled by the American Health Insurance Portability and Accountability Act. These devices must be protected from “hardware incompatibility, the lack of cellular telephone coverage, power outages, and unexpected automated operating system software updates requiring computer reboots” (Kang et al. 2010: 1584). However, they do not currently have guidelines with regard to privacy and surveillance. Researchers (e.g., Kang et al. 2010) recommend that privacy and reliability be primary goals of future monitoring technology development.

Kang et al. (2010) reviewed issues faced by internet and wireless technology and pointed out that data from monitoring systems require appropriate and secure computer systems and data infrastructure. Common technologies include “store and forward” systems and “live interactive devices” (Kang et al. 2010). These researchers point out that issues may occur during transmission from the device collecting the information to the analysis/storage site. For example, health surveillance data in some cases is sent via wireless connection and transmitted to the web-server via Bluetooth and is vulnerable to unauthorized access (Evangelista 2015; Mihailidis et al. 2008).

As noted, technological solutions have been marketed to monitor the growing trend of social isolation in older adults. Specifically, the use of socio-metrics, already used in workplaces to infer interactions with other people based on movement, location, and speech data, are being recast in other settings. Premised on forms of social network engagement, these wearable devices have the ability to detect the presence of others wearing the device and to record the tone of voice used by these individuals (Kang et al. 2010). There are also apps that enable the use of a cell phone to track “an older person’s social engagement and life-space and detect social isolation” (Kang et al 2010: 1581). Given that positive and/or meaningful social activity is linked to good health outcomes, we speculate further socio-metric devices and apps may be used to monitor social interactions and personal analytics among older adults.

In response to the designation of older adults as an at-risk group, various discussed AAL technologies have been developed to measure movement and displacement. The latest iteration of AAL technologies is Emerald,² a non-contact sensor technology that allows the company to “leverage the fact that wireless signals in the WiFi frequencies traverse walls and reflect off the human body” (Zhao et al. 2018: 1). This technology is being used as an AAL system to record movement, respiration, activities of daily living, and sleep patterns. However, unlike other discussed technologies, Emerald does not require any sensors or wearables. Instead, the wall-mounted device is able to record data throughout the home. The developers believe that it will remove adherence issues because users do not need to interact with it in any way.

Wearables and related IoT-enabled devices are increasingly vanishing, proliferating, and becoming everyday forms of monitoring. However, as “unobtrusive detection” is marketed as a social good, surveillance potentials are increasingly overshadowed by promises of convenience and safety or other false binaries. The consequences of this mentality, while in many cases attempting to protect the most vulnerable, run the risk of amplifying and exacerbating vulnerabilities as the ageing enterprise and the data it’s amassing fall under the purview of surveillance capitalism. While these technologies may help some older adults age

² See <https://www.emeraldinno.com/clinical/> [accessed June 7, 2020].

in place and retain autonomy, the potentials of these surveillance technologies may simultaneously infringe upon privacy, autonomy, and self-determination. As the data of older adults are increasingly collected and commodified, stronger consumer protection and proactive privacy legislation is required to safeguard, but also purposefully connect rights to, privacy, dignity, and ageing in place.

Conclusion

This scoping review identified three primary types of gerontechnology used for the health-related surveillance of older adults: wearable devices, smart home and AAL monitoring, and tablets and/or smartphones. Specifically, our scoping review explored the data being collected, examined the intended and unintended uses for these data, and synthesized the privacy and surveillance concerns of older adults. Overall, possibly as a result of this loss of privacy, many older adults prefer wearable devices rather than AAL because they were unobtrusive, “worked outside the home and increased participants’ mobility without compromising safety” (Pietrzak, Cotea, and Pullman 2014: 110). Despite the perceived convenience, older adults clearly expressed concerns about the risk of violating autonomy and privacy by exposing the most intimate details of their lives to scrutiny through health-related surveillance. However, the bottom line is that “being monitored is not something either group [caregivers or care-receivers] looked forward to” (Epstein et al. 2016: 49). Similar to broader findings concerning meaningful informed consent and purpose limitation, the reviewed studies highlighted the importance of clear terms and conditions to ensure older adults understand the extent of the surveillance to which they are agreeing.

Beyond more proactive privacy protections, we contend far more consideration needs to be paid to the relations that underlie gerontechnologies. Developed and promoted as a means of securing and caring for older adults, the forms of surveillance these technologies enable are perhaps antithetical to broader conceptions of care. While we concede that, in some cases, monitoring the health and location of an older adult may be beneficial to their care providers and families, more *care* needs to be paid to the data produced, analyzed, and retained by these devices. Moreover, more care needs to be paid to how these data are commodified, shared, and combined. On a spectrum of care and control, the weak purpose limitation of the data collected by these devices demonstrates the alignment of the ageing enterprise with surveillance capitalism. This political economy of ageing vis-à-vis surveillance capitalism profoundly impacts the privacy of older adults using gerontechnology since “monetization opportunities are thus associated with a new global architecture of data capture and analysis that produces rewards and punishments aimed at modifying and commoditizing behavior for profit” (Zuboff 2015: 85). In other words, these IoT-enabled gerontechnologies not only “secure” the elderly body (Kenner 2008) but commodify it. Rather than limited understandings of care or safety, the considerations need to extend to the data these devices produce.

This project has begun to explore the scrutiny older adults receive through AAL and wearable technologies and the attendant privacy risks. We approached this analysis from a privacy perspective and see these concerns as social not health issues. These findings have the potential to inform public policy surrounding the development of big data reporting on the current and predicted health status of older adults. Although the data of concern here are health related, the issue is one of privacy and autonomy in a vulnerable population. We recommend future research continues to explore the intersections of the ageing enterprise and surveillance capitalism across a variety of contexts, sites, and populations. More empiric research with clear policy recommendations is needed.

References

- Alley, Stephanie, Stephanie Schoeppe, Diana Guertler, Cally Jennings, Mitch J. Duncan, and Corneel Vandelanotte. 2016. Interest and Preferences for Using Advanced Physical Activity Tracking Devices: Results of a National Cross-Sectional Survey. *BMJ Open* 6 (7): 1–8.
- Aloulou, Hamdi, Mounir Mokhtari, Thibaut Tiberghien, Jit Biswas, Clifton Phua, Jin Hong Kenneth Lin, and Philip Yap. 2013. Deployment of Assistive Living Technology in a Nursing Home Environment: Methods and Lessons Learned. *BMC Medical Informatics and Decision Making* 13 (1): 42–42.

- Anderson, Monica, and Andrew Perrin. 2017. Tech Adoption Climbs Among Older Adults. *Pew Research Centre*, May 17. <http://www.pewinternet.org/2017/05/17/technology-use-among-seniors/> [accessed December 8, 2017].
- Arksey, Hilary, and Lisa O'Malley. 2005. Scoping Studies: Towards a Methodological Framework. *International Journal of Social Research Methodology* 8 (1): 19–32.
- Ball, Kirstie. 2019. Review of Zuboff's *The Age of Surveillance Capitalism*. *Surveillance & Society* 17 (1/2): 252–256.
- Baumann, Michael. 2010. Pew Report: Digital Natives Get Personal. *Information Today* 27 (10): 18.
- Berridge, Clara. 2016. Breathing Room in Monitored Space: The Impact of Passive Monitoring Technology on Privacy in Independent Living. *The Gerontologist* 56 (5): 807–816.
- Blackman, Stephanie, Claudine Matlo, Charisse Bobrovitskiy, Ashley Waldoch, Mei Lan Fang, Piper Jackson, Alex Mihailidis, Louise Nygård, Arlene Astell, and Andrew Sixsmith. 2016. Ambient Assisted Living Technologies for Aging Well: A Scoping Review. *Journal of Intelligent Systems* 25 (1): 55–69.
- boyd, danah. 2016. Undoing the Neutrality of Big Data. *Florida Law Review Forum* 67: 226–232.
- Caine, Kelly E., Celine Y. Zimmerman, Zachary Schall-Zimmerman, William R. Hazlewood, L. Jean Camp, Katherine H. Connelly, Lesa L. Huber, and Kalpana Shankar. 2011. DigiSwitch: A Device to Allow Older Adults to Monitor and Direct the Collection and Transmission of Health Information Collected at Home. *Journal of Medical Systems* 35 (5): 1181–1195.
- Carver, Lisa F. 2018. Turning Your Health Data into a “Wellness Score” Might Not Be Good for You. *The Conversation*, August 7. <https://theconversation.com/turning-your-health-data-into-a-wellness-score-might-not-be-good-for-you-100641> [August 7, 2018].
- Carver, Lisa F., Rob Beamish, Susan P. Phillips, and Michelle Villeneuve. 2018. A Scoping Review: Social Participation as a Cornerstone of Successful Aging in Place among Rural Older Adults. *Geriatrics* 3 (4): 75–90.
- Centers for Disease Control and Prevention. 2009. Healthy Places Terminology. *CDC*. <https://www.cdc.gov/healthyplaces/terminology.htm> [accessed December 8, 2017].
- Chakraborty, Rajarshi, Claire Vishik, and H. Raghav Rao. 2013. Privacy Preserving Actions of Older Adults on Social Media: Exploring the Behavior of Opting Out of Information Sharing. *Decision Support Systems* 55 (4): 948–56.
- Chung, Arlene E., Robert S. Sandler, Millie D. Long, Sean Ahrens, Jessica L. Burris, Christopher F. Martin, Kristen Anton, and Michael D. Kappelman. 2016. Harnessing Person-Generated Health Data to Accelerate Patient-Centered Outcomes Research: The Crohn's and Colitis Foundation of America PCORnet Patient Powered Research Network (CCFA Partners). *Journal of the American Medical Informatics Association* 23 (3): 485.
- Constantiou, Ioanna D., and Jannis Kallinikos. 2015. New Games, New Rules: Big Data and the Changing Context of Strategy. *Journal of Information Technology* 30 (1): 44–57.
- Courtney, Karen L., George Demeris, Marilyn Rantz, and Marjorie Skubic. 2008. Needing Smart Home Technologies: The Perspectives of Older Adults in Continuing Care Retirement Communities. *Journal of Innovation in Health Informatics* 16 (3): 195–201.
- Epstein, Iris, Allan Aligato, Tyler Krimmel, and Alex Mihailidis. 2016. Older Adults' and Caregivers' Perspectives on In-Home Monitoring Technology. *Journal of Gerontological Nursing* 42 (6): 43–50.
- Essén, Anna. 2008. The Two Facets of Electronic Care Surveillance: An Exploration of the Views of Older People Who Live with Monitoring Devices. *Social Science & Medicine* 67 (1): 128–136.
- Estes, C.L. 1979. *The Aging Enterprise: A Critical Examination of Social Policies and Services for the Aged*. San Francisco: Jossey-Bass Publishers.
- Evangelista, Lorraine S., Debra K. Moser, Jung-Ah Lee, Alison A. Moore, Hassan Ghasemzadeh, Majid Sarrafzadeh, and Carol M. Mangione. 2015. Examining Older Adults' Perceptions of Usability and Acceptability of Remote Monitoring Systems to Manage Chronic Heart Failure. *Gerontology and Geriatric Medicine* 1: 1–6.
- Fox, Susannah. 2006. Are “Wired Seniors” Sitting Ducks? *Pew Internet and American Life Project*, April 11. <http://www.pewinternet.org/2006/04/11/are-wired-seniors-sitting-ducks/> [accessed December 8, 2017].
- Gellad, Walid F., Haiden A. Huskamp, Kathryn A. Phillips, and Jennifer S. Haas. 2006. How the New Medicare Drug Plan Could Affect Vulnerable Populations. *Health Affairs* 25 (1): 248–255.
- Glasse, Lou. 1990. Growing Old: It's Different for Men and Women. *Generations* 14 (3): 73–75.
- Goffman, Erving. 1961. *Asylums: Essays on the Social Situation of Mental Patients and Other Inmates*. Garden City, N.Y.: Anchor Books.
- Gram-Hanssen, Kirsten, and Sarah J Darby. 2018. “Home Is Where the Smart Is”? Evaluating Smart Home Research and Approaches Against the Concept of Home. *Energy Research & Social Science* 37: 94–101.
- Hargittai, Eszter, and Kerry Dobransky. 2017. Old Dogs, New Clicks: Digital Inequality in Skills and Uses Among Older Adults. *Canadian Journal of Communication* 42 (2): 195–212.
- Hargreaves, Tom, and Charlie Wilson. 2017. *Smart Homes and Their Users*. New York, NY: Springer.
- Hedman, Annicka, Eva Lindqvist, and Louise Nygård. 2016. How Older Adults with Mild Cognitive Impairment Relate to Technology as Part of Present and Future Everyday Life: A Qualitative Study. *BMC Geriatrics* 16 (1): 73.
- Hwang, Eunju. 2008. Exploring Aging-in-Place Among Chinese and Korean Seniors in British Columbia, Canada. *Ageing International* 32 (3): 205–218.
- Kang, Hyun Gu, Diane F. Mahoney, Helen Hoenig, Victor A. Hirth, Paolo Bonato, Ihab Hajjar, and Lewis A. Lipsitz. 2010. In situ Monitoring of Health in Older Adults: Technologies and Issues. *Journal of the American Geriatrics Society* 58 (8): 1579–1586.
- Kenner, Alison Marie. 2008. Securing the Elderly Body: Dementia, Surveillance, and the Politics of “Aging in Place.” *Surveillance & Society* 5 (3): 252–269.

- Kerr, Ian, and Jessica Earle. 2013. Prediction, Preemption, Presumption: How Big Data Threatens Big Picture Privacy. *Stanford Law Review* 66 (65): 65–72.
- Kezer, Murat, Barış Sevi, Zeynep Cemalcilar, and Lemi Baruh. 2016. Age Differences in Privacy Attitudes, Literacy and Privacy Management on Facebook. *Cyberpsychology: Journal of Psychosocial Research on Cyberspace* 10 (1).
- Koh, Ahyeon, Daeshik Kang, Yeguang Xue, Seungmin Lee, Rafal M. Pielak, Jeonghyun Kim, Seunghwan Min, Anthony Banks, Philippe Bastien, Megan C. Manco, Liang Wang, Kaitlyn R. Ammann, Kyung-In Jang, Phillip Won, Seungyong Han, Roozbeh Ghaffari, Ungyu Paik, Marvin J. Slepian, Guive Balooch, Yonggang Huang, and John A. Rogers. 2016. A Soft, Wearable Microfluidic Device for the Capture, Storage, and Colorimetric Sensing of Sweat. *Science Translational Medicine* 8 (366): 366ra165.
- Leist, Anja K. 2013. Social Media Use of Older Adults: A Mini-Review. *Gerontology* 59 (4): 378–384.
- Livingstone, Sonia. 2008. Taking Risky Opportunities in Youthful Content Creation: Teenagers' Use of Social Networking Sites for Intimacy, Privacy and Self-Expression. *New Media Society* 10 (3): 393–411.
- Lyon, David. 2007. *Surveillance Studies: An Overview*. Cambridge, MA: Polity.
- Lyon, David. 2014. Surveillance, Snowden, and Big Data: Capacities, Consequences, Critique. *Big Data and Society* 1 (2): 1–13.
- Lyon, David. 2017. Surveillance Culture: Engagement, Exposure, and Ethics in Digital Modernity. *International Journal of Communications* 11: 824–842.
- Maalsen, Sophia, and Jathan Sadowski. 2019. The Smart Home on FIRE: Amplifying and Accelerating Domestic Surveillance. *Surveillance & Society* 17 (1/2): 118–124.
- Malhotra, Naresh K., Sung S. Kim, and James Agarwal. 2004. Internet Users' Information Privacy Concerns (IUIPC): The Construct, the Scale, and a Causal Model. *Information Systems Research* 15 (4): 336–355.
- Masterson Creber, Ruth M., Kathleen T. Hickey, and Mathew S. Maurer. 2016. Gerontechnologies for Older Patients with Heart Failure: What is the Role of Smartphones, Tablets, and Remote Monitoring Devices in Improving Symptom Monitoring and Self-Care Management? *Current Cardiovascular Risk Reports* 10 (10): 1–8.
- Mihailidis, Alex, Amy Cockburn, Catherine Longley, and Jennifer Boger. 2008. The Acceptability of Home Monitoring Technology Among Community-Dwelling Older Adults and Baby Boomers. *Assistive Technology* 20 (1): 1–12.
- Miltgen, Caroline Lancelot, and Dominique Peyrat-Guillard. 2014. Cultural and Generational Influences on Privacy Concerns: A Qualitative Study in Seven European Countries. *European Journal of Information Systems* 23 (2): 103–125.
- Minuk, Lisa. 2006. Why Privacy Still Matters: The Case Against Prophylactic Video Surveillance in For-Profit Long-Term Care Homes. *Queen's Law Journal* 32 (3): 224–277.
- Morris, Anne. E-Literacy and the Grey Digital Divide: A Review with Recommendations. *Journal of information literacy* 1 (3): 13–28.
- Mortenson, W. Ben, Andrew Sixsmith, and Ryan Woolrych. 2015. The Power(s) of Observation: Theoretical Perspectives on Surveillance Technologies and Older People. *Ageing and Society* 35: 512–530.
- Moscardelli, Deborah M., and Richard Divine. 2007. Adolescents' Concern for Privacy When Using the Internet: An Empirical Analysis of Predictors and Relationships with Privacy-Protecting Behaviors. *Family and Consumer Sciences Research Journal* 35 (3): 232–252.
- Murakami Wood, David. 2014. Vanishing Surveillance: Ghost-Hunting in the Ubiquitous Surveillance Society. In *Invisibility Studies: Surveillance, Transparency and the Hidden in Contemporary Cultures*, edited by Henriette Steiner and Kristin Veel, 281–300. New York: Peter Lang.
- O'Brien, Sean, and Michael Kwet. 2017. #BlackFriday Announcement from Privacy Lab. *Privacy Lab*, November 24. <https://privacylab.yale.edu/trackers.html> [accessed December 8, 2017].
- Office of the Privacy Commissioner of Canada. 2014. Wearable Computing - Challenges and Opportunities for Privacy Protection. *Office of the Privacy Commissioner of Canada*, January. https://www.priv.gc.ca/en/opc-actions-and-decisions/research/explore-privacy-research/2014/wc_201401/ [accessed December 8, 2017].
- Patel, Mitesh S., Luca Foschini, Gregory W. Kurtzman, Jingsan Zhu, Wenli Wang, Charles A. L. Rareside, and Susan M. Zbikowski. 2017. Using Wearable Devices and Smartphones to Track Physical Activity: Initial Activation, Sustained Use, and Step Counts Across Sociodemographic Characteristics in a National Sample. *Annals of Internal Medicine* 167 (10): 755–757.
- Peetoom, Kirsten K. B., Monique A. S. Lexis, Manuela Joore, Carmen D. Dirksen, and Luc P. De Witte. 2015. Literature Review on Monitoring Technologies and Their Outcomes in Independently Living Elderly People. *Disability and Rehabilitation: Assistive Technology* 10 (4): 271–294.
- Percival, John, and Julianne Hanson. Big Brother or Brave New World? Telecare and Its Implications for Older People's Independence and Social Inclusion. *Critical Social Policy* 26 (4): 888–909.
- Pevnick, Joshua M., Garth Fuller, Ray Duncan, and Brennan M. R. Spiegel. 2016. A Large-Scale Initiative Inviting Patients to Share Personal Fitness Tracker Data with Their Providers: Initial Results. *PLoS One* 11 (11): 1–5.
- Pietrzak, Eva, Cristina Cotea, and Stephen Pullman. 2014. Does Smart Home Technology Prevent Falls in Community-Dwelling Older Adults: A Literature Review. *Informatics in Primary Care* 21 (3): 105–112.
- Quan-Haase, Anabel, Kim Martin, and Kathleen Schreurs. 2016. Interviews with Digital Seniors: ICT Use in the Context of Everyday Life. *Information, Communication & Society* 19 (5): 691–707.
- Rantz, Marilyn J., Marjorie Skubic, Greg Alexander, Myra A. Aud, Bonnie J. Wakefield, Colleen Galambos, Richelle J. Koopman, and Steven J. Miller. 2010. Improving Nurse Care Coordination with Technology. *Computers, Informatics, Nursing* 28 (6): 325–332.
- Rantz, Marilyn J., Marjorie Skubic, Mihail Popescu, Colleen Galambos, Richelle J. Koopman, Gregory L. Alexander, Lorraine J. Phillips, Katy Musterman, Jessica Back, and Steven J. Miller. 2015. A New Paradigm of Technology-Enabled "Vital Signs" for Early Detection of Health Change for Older Adults. *Gerontology* 61 (3): 281–290.

- Reitz, Michele, Brian Blau, and Angela McIntyre. 2016. Forecast: Wearable Electronic Devices, Worldwide, 2016. *Gartner Research*, January 19. <https://www.gartner.com/en/documents/3187421/forecast-wearable-electronic-devices-worldwide-2016> [accessed December 8, 2017].
- Richardson, Steven, and Debra Mackinnon. 2018. Becoming Your Own Device: Self-Tracking Challenges in the Workplace. *Canadian Journal of Sociology* 43 (3): 265–289.
- Rosenberger, Mary E., Matthew P. Buman, William L. Haskell, Michael V. McConnell, and Laura L. Carstensen. 2016. Twenty-Four Hours of Sleep, Sedentary Behavior, and Physical Activity with Nine Wearable Devices. *Medicine and Science in Sports and Exercise* 48 (3): 457–465.
- Schmarzo, Bill. 2013. *Big Data: Understanding How Data Powers Big Business*. Indianapolis, IN: John Wiley and Sons.
- Smith, H. Jeff, Sandra J. Milberg, and Sandra J. Burke. 1996. Information Privacy: Measuring Individuals' Concerns about Organizational Practices. *MIS Quarterly* 20 (2): 167–196.
- Steele, Robert, Amanda Lo, Chris Secombe, and Yuk Kuen Wong. Elderly Persons' Perception and Acceptance of Using Wireless Sensor Networks to Assist Healthcare. *International Journal of Medical Informatics* 78 (12): 788–801.
- Steeves, Val. 2008. If the Supreme Court Were on Facebook: Evaluating the Reasonable Expectation of Privacy Test from a Social Perspective. *Canadian Journal of Criminology and Criminal Justice* 50 (3): 331–347.
- Strengers, Yolande, Larissa Nicholls, and Cecily Maller. 2016. Curious Energy Consumers. *Journal of Consumer Culture* 16: 761–780.
- Yang, Che-Chang, and Yeh-Liang Hsu. 2010. A Review of Accelerometry-Based Wearable Motion Detectors for Physical Activity Monitoring. *Sensors* 10 (8): 7772–7788.
- Youn, Seounmi. 2009. Determinants of Online Privacy Concern and its Influence on Privacy Protection Behaviors Among Young Adolescents. *Journal of Consumer Affairs* 43 (3): 389–418.
- Zhao, Mingmin, Tianhong Li, Mohammad Abu, Alsheikh Yonglong, Tian Hang Zhao, Antonio Torralba, and Dina Katabi. 2018. Through-Wall Human Pose Estimation Using Radio Signals. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*, 7356–7365. Salt Lake City, Utah.
- Zuboff, Shoshana. 2015. Big Other: Surveillance Capitalism and the Prospects of an Information Civilization. *Journal of Information Technology* 30 (1): 75–89.