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Technologies and Health Inequities

Stefan Timmermans and Rebecca Kaufman

Department of Sociology, University of California, Los Angeles, California 90095-1551, USA;
email: Stefan@soc.ucla.edu

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Abstract

Health technologies aim to improve individual and population health, but they may also exacerbate health disparities. Focusing on the specific design features of technologies, their availability, and their use, we present a conceptual framework to examine how health technologies may benefit some groups more than others by combining the theory of fundamental causes with a technology-in-practice approach. We examine three classes of technologies that have been associated with health inequities: once-advanced technologies such as kidney dialysis and transplantation for end-stage renal disease, which have been plagued by issues of scarcity and fair distribution, generating racial disparities; the highly anticipated precision medicine promising to change the focus from population to individualized medicine; and digital technologies, which may herald a democratization of health care.

INTRODUCTION

From pregnancy tests and folic acid supplements to ultrasounds at prenatal visits, health technologies permeate our lives from before we are born until we die. The World Health Organization defines health technologies as the “application of organized knowledge and skills in the form of devices, medicines, vaccines, procedures and systems developed *to solve a health problem and improve quality of lives*” (WHO 2007, p. 106; emphasis added). Technologies range from everyday tools to the most advanced genomic and robot-assisted surgery devices and span the full range of care: disease prevention, diagnosis, monitoring, prognosis, and treatment. They include physical objects, procedures, social interventions, and health-care systems.

With such a broad definitional scope, anything of interest to medical professionals, health policy makers, and sociologists can be studied through health technologies. To limit this review’s ambit, we take seriously the mandate of health technologies to “solve a health problem and improve quality of lives” and are particularly interested in how directly or indirectly technologies generate, perpetuate, or reduce health inequities. Technologies may improve the quality of some lives and harm others, and we are interested in the social sorting and patterning of technological changes. Indeed, at the same time that health technologies continue to revolutionize health care, health disparities in the United States have mostly been increasing (Bleich et al. 2012), but these developments are not necessarily causally linked.

Early sociologists, swept up by the optimism that technologies would advance medicine, paid little attention to the health rationale behind technologies. In one of the pioneering studies of health technologies, Coleman et al. (1966) examined the diffusion of the antibiotic tetracycline and established the importance of influencers: early adopters of new technologies spreading the technologies in their networks through a process of social contagion following the classic S-curve of adoption.¹ Yet, while it was critical as a diffusion and social network study, the researchers ignored why the drug was developed, alternative treatments available to clinicians, and the medical needs of patients (Blume 2013). Considering the disregard for the technology’s rationale, it is unsurprising that a later study showed the importance of contextual factors in the diffusion of tetracycline such as an intensive marketing campaign with aggressive pricing, rendering social influence largely a methodological artifact (Van den Bulte & Lilien 2001). Still, diffusion studies may explain why health technologies provide a benefit windfall for early adopters, carrying over into social stratification if some groups are more likely to adopt than others (Rogers 2003).

While health technologies have been singled out for decades as central actors in health care, their role in creating and perpetuating health inequities has been of more recent sociological interest. In her 1976 *Annual Review of Sociology* review on advanced medical technologies, Renée Fox (1976) linked the proliferation of medical technologies to the emergence of the field of bioethics and defined the distinct task of sociologists to examine the social fallout and opportunities of organ transplantation, dialysis, genetics, and medical experimentation. She examined shifts in patient-doctor interaction, the gift exchange between organ donor and recipient, and challenges to medical authority brought by these technologies. She predicted that medical technologies heralded a new stage of modernity that would bring moral alienation to health care as well as opportunities for generosity. However, the role of these technologies in addressing health inequities was not part of the research agenda of early generations of sociologists.²

¹ Early in the diffusion process, relatively few individuals adopt the innovation, but the rate of uptake accelerates and finally plateaus as fewer remaining individuals adopt or receive it.

² Fox’s review also drew attention to a shift from medical to health technologies. When Fox wrote, technology was viewed as medical, reflective of the dominant role of physicians in health care.

Over the last decades, the social science literatures on health disparities and medical technologies have continued on two parallel tracks. Scholars documenting the social determinants of health often start from the assumption that health care (including medical technologies) alone is insufficient to improve population health (e.g., Braveman et al. 2011), while the science, technology, and society literature on medical technologies has been more focused on how technologies reconfigure care practices and subjectivities than on the social stratification following the implementation of technologies (e.g., Mol 2008). Yet, the pharmaceuticalization of public health (Biehl 2009), which relies on medicines to achieve population health goals, and the turn to vaccines and screening programs to protect community health are only some of the reasons to bring these literatures into dialog with each other and assess for whom technologies improve health.

In the following sections, we situate the broad role of health technologies in health inequities and offer a conceptual framework for studying the effects of technologies on health disparities by combining the theory of fundamental causes with a technology-in-practice approach. Then we zoom in on three classes of technologies that have been associated with inequity: older advanced technologies such as organ and tissue transplantation, which have been plagued by issues of scarcity and fair distribution; the highly anticipated precision medicine promising to change the focus from population to individualized medicine; and digital technologies, which may herald a democratization of health care.

TECHNO-UTOPIA AND TECHNO-DYSTOPIA

Invested with hope, hype, and fear, health technologies thrive as bandwagons (Fujimura 1988) and buzzwords (Vincent 2014). They have become heroes and villains in contemporary health care narratives. On the hero side, recent gains in life expectancy have been attributed to the implementation of medical technologies. In 1900, the life expectancy in the United States was 47 years. A century later, it had increased to 77 years (Arias 2006). The reduction of mortality in the first half of the twentieth century was due to population-based public health interventions such as improved sanitation, public water treatment, sewage management, food inspection, and municipal garbage collection. These interventions dovetailed with better housing conditions, air quality improvements, child labor laws, and higher literacy rates (McKeown 1976).

In the second part of the twentieth century, researchers estimate that the average life expectancy in the United States increased by a further 7 years, and that half of that increase was attributable to improvements in technology-driven therapies such as pulmonary surfactant therapy, the neonatal intensive care unit for reducing infant mortality (Frisbie et al. 2004), and various cardiac interventions for reducing cardiac diseases (Cutler 2004). Similar to the therapeutic transformation of HIV, health technologies allow health-care providers to diagnose and treat illnesses in ways that were previously impossible, turning fatal scourges into manageable chronic conditions.

At the same time, life expectancy itself increases continuously with income and education. Between 2001 and 2014, the gap in life expectancy between the richest 1% and the poorest 1% of individuals was 14.6 years for men and 10.1 years for women, and this discrepancy increased over that period (Chetty et al. 2016). The richest Americans gained approximately three years in longevity, but the poorest Americans experienced no gains.³ Life expectancy actually declined in the United States between 2014 and 2017, mostly among lower-educated White males due to drug overdose deaths and other deaths of despair (Case & Deaton 2017, Sasson & Hayward 2019).

³While this research provided most of the support for the hypothesis that the poor did best when they lived in wealthy areas [suggesting a wealth spillover effect (Timmermans et al. 2014)], differences in access to and use of health technologies may explain some stratification.

On the villain side, we can distinguish between a humanist and a health policy critique. Health technologies symbolize the corrosive dehumanization of contemporary medicine, with care providers treating numbers, tests, and screens rather than the patient's embodied lifeworld. The same technologies embraced for their ability to save lives may lead to social suffering and isolation. Health technologies are also associated with creeping medicalization, where risk factors such as elevated cholesterol levels are turned into proto-diseases (Rosenberg 2007). In addition, health technologies have had far-reaching effects on the body, identity, and sociality of the patient and at the expense of the realms of work, religion, the family, and community (for a review, see Casper & Morrison 2010). While this literature does not always address health disparities directly, research has examined how the very design of technologies assumes patients and clinicians have certain abilities and resources and that the technological set-up makes it more likely for some actors to appropriate the technology for their purposes (Akrich 1992, Oudshoorn & Pinch 2003).

Economists also consider health technologies in the aggregate to be a primary driver of increasing health-care expenditures (Sorenson et al. 2013). Although there is variation on, for instance, whether new technologies substitute for existing technologies, and while some technologies may increase cost for some but be cost-effective for other patients, most medical innovations are cost-increasing. This is not necessarily problematic if the benefits of health technologies outweigh their cost and if their opportunity cost remains favorable in comparison to, for instance, investments in education or the environment. Still, especially in the United States, increasing health-care costs, with technologies leading the way, exacerbate health-care access problems.

Both the hero and villain narratives of health technologies risk succumbing to technological determinism: the assumption that technological developments are the key guiding force in how society, or health, is structured. The narratives tend to exaggerate technology's ability to bring about social change, a tendency exacerbated by the fact that many technologies are studied for their anticipated rather than their actual consequences. Drawing from science and technology studies, sociologists have been studying technologies in practice (Timmermans & Berg 2003), following health technologies from laboratory bench to bedside and seeing how these technologies change existing medical work. The technology-in-practice approach brackets the technologies' intended aims and studies both intended and unintended effects of technologies as they are experienced and mediate between different health-care goals. This approach often finds that the hope and hype surrounding health technologies remain unfulfilled and that technologies generate more nuanced changes instead. The approach draws attention to specific types of technologies, who has access to the technology and whose work/lives are affected by the technology, and how the technology is used in practice. We elaborate on these dimensions after reviewing the theory of fundamental causes.

FUNDAMENTAL CAUSES OF DISEASE

How can we make sense of this sharp bifurcation where technologies have a proven record of saving lives while also fundamentally altering the nature of health care in ways that exacerbate access, cost, and health outcome inequities? Link & Phelan's (1995; Phelan et al. 2010) theory of social conditions as fundamental causes of health inequities posits that the advantages of social class—money, knowledge, beneficial social networks, skills, and power—allow the wealthy to proactively take advantage of biomedical technologies and obtain better health outcomes for a wide range of diseases. These resources are flexible, multipurpose, and transportable, and they work through various risk factors that mitigate health outcomes. They can also be exploited in changing conditions with new diseases and health risk factors. Lutfey & Freese (2005) elaborated that when *X* is a fundamental cause of *Y*, this implies that *X* and *Y* are linked through multiple mechanisms. If health policies were able to sever one link (e.g., implementing universal health insurance), the

relationship between socioeconomic status (SES) and health outcomes would not disappear, but it would shift or reemerge in different forms over time. To neutralize a fundamental cause would thus require a radical transformation.

While the theory was initially formulated to explain class disparities, other factors such as gender (Lutfey et al. 2009, Rieker & Bird 2008), age, and racial-ethnic disparities (Phelan et al. 2010) are also closely associated with resource access. What kind of social disparity matters most? Weiss et al. (2018) noted the variety of variables used to assess relative advantage due to social positions: geographical locations (urban-rural); ascriptive factors such as race, class, and gender; and factors that are to a limited extent amendable such as education, income, and insurance or employment status. The choice of variable will itself influence whether an impact on social inequality is observable. We follow the lead of the social science literature: Most of the studies look at variation by SES, some disparities due to health technologies are studied for gender or racial differences, and others introduce new forms of inequity (e.g., digital literacy).

Researchers found support for the theory of fundamental causes prediction that new health technologies will benefit those with higher SES and nonminority ethnic and racial backgrounds. While at a general level, health technologies have salutary health effects, they nevertheless tend to exacerbate health inequities, especially in the early stages of their rollout. Once mammography was identified as a preventive detection tool for breast cancer, SES-based disparities emerged (Link et al. 1998). Socioeconomic gradients of health are generally greatest for preventable and treatable diseases (Phelan et al. 2004). Across a broad range of diseases, improvements in health technologies benefit those with higher levels of education (Glied & Lleras-Muney 2008). Better-educated people may have an information advantage, be adept at adopting technologies in their early stages, have access to health-care providers more familiar with technological innovations, and have more resources to pay for technologies. Polonijo & Carpiano (2013) found that lower-SES and racial-minority parents were less likely to know about HPV vaccines, less likely to receive a recommendation from a health-care provider, and less likely to initiate the three-shot vaccination series. A study of the prescription of corticosteroid metered dose inhalers for asthma found that, initially (1989–1990), minority patients were less likely than nonminority patients to have such an inhaler prescribed, but by 1995–1996, this difference had disappeared (Ferris et al. 2006). Similarly, African American patients were initially less likely to be treated with implantable cardioverter defibrillators, but the discrepancy declined over time (Stanley et al. 2007).

The inverse equity hypothesis predicts that new health interventions will initially reach those of higher SES, but the early increase in inequity ratios will be followed by a reduction when higher-SES people have reached a threshold level and those of lower SES gain greater access to the interventions. Research on the diffusion of coronary procedures, for instance, follows the inverse equity hypothesis (Korda et al. 2011).

Chang & Lauderdale (2009) offered an important qualification to the theory of fundamental causes by arguing that this temporal pattern of initial benefits for high-SES and nonminority groups varies by type of technology. They proposed that the nature of technological change and the extent of its adoption affect whether technologies will increase or contract health disparities. Generally, high-SES groups are heavier users of health care and may therefore reap its benefits, widening health disparities. However, technologies can be subdivided into those that require complex administration regimes and those that simplify treatment. Complex technologies such as antiretroviral therapy for HIV in the mid-1990s (highly active antiretroviral therapy, or HAART), which required multiple medicines and up to 24 pills to be timed in a specific daily sequence, and those that are affected by diet may benefit wealthier patients more. In contrast, simple technologies such as drugs for hypertension (e.g., beta-blockers and diuretics), which are easy for anyone to take and depend less on demanding lifestyle changes, may instead reduce health disparities.

Studying the effect of statins on cholesterol levels between 1976 and 2004, Chang & Lauderdale (2009) found that income gradients for cholesterol were initially positive but then reversed in the era of widespread statin use. Once statins were available, overall cholesterol levels declined across income levels, but the wealthy experienced a much larger decline in lipid measures. The benefits of cholesterol management for higher-SES patients suggest that health technologies can have an effect on resources based on the nature of technological change: If a technology requires more resources for monitoring and managing side effects (like for HIV treatment or statin treatment), then it is likely that the wealthy may benefit more, but if the health technology levels the playing field (like with vaccines or blood pressure medication), then disparities may contract. As Hernandez (2013) also showed, health-care providers and other stakeholders can simplify technologies by using uniform screening protocols.

The specific material form of a technology, its availability, and actual use thus matter for how a technology may affect race, gender, age, and class health inequities. Health technologies aimed at entire populations, requiring little effort, individual motivation, or behavioral changes, are likely going to be more effective and equalizing (e.g., fluoridation of the water supply, environmental controls for air pollution). Technologies that are complex, demand resources to access them, and require mediation—either through the health-care system or through individual uptake—are going to offer opportunities for the advantaged to game lifesaving or life-enhancing tools to their advantage.

TECHNOLOGY HEALTH EFFECTS MODEL

We can combine a technology-in-practice approach with the theory of fundamental causes and focus on how health technologies produce health disparities. The relationship between fundamental causes and health outcomes originates from the resources people acquire individually and collectively (e.g., money, knowledge). These are leveraged at different levels of engaging with health: individual, interpersonal, organizational, state, and policy. Reliance on technologies to solve health issues is one critical mediating social mechanism producing health disparities. It may be most logically classified as a form of health care (at the organizational level), but actors at each one of the levels are able to shape the type of health technology, its access and availability, and its use. For instance, state regulators may put restrictions on the availability of pharmaceuticals (the technology), which would be an instance of regulation that has downstream effects on the drug's affordability and availability.

From the technology-in-practice approach we know that health technologies are not immutable black boxes having uniform effects on all users but that the kind of health technology, its origins, its adoption, and the actual use of the technology will produce a variety of intended and unintended effects on different kinds of users. For these different users, a health technology's effects on health outcomes vary from no effect to unequally distributed and equally distributed effects. The theory of fundamental causes predicts that advantaged people will benefit most, perpetuating and generating health disparities. However, some health technologies may explicitly target those with fewer resources [e.g., income support, subsidized health care, and nutrition programs (Mechanic 2007)], while other technologies may explicitly be directed at minority groups [e.g., the controversy around cochlear implants and deaf culture (Blume 2013)]. It should also be noted that if some groups are more likely to take advantage of health technologies, they will only benefit if the technology is actually health promoting. Because they can afford interventions, the wealthy are at risk for overtreatment (Welch 2011) or subverting technologies for other purposes. Lutfey & Freese (2007), for instance, noted that White middle-class diabetic girls deliberately aimed to keep their glucose levels high because of the side effect of weight loss.

Combining both theories, we can point to specific ways that health technologies are likely to produce health disparities.

Technological Design

Variation in a health technology's design shape circumscribes the users of the technology and sets the technology apart from competitors. A medication, for example, may be available with or without prescription, required to be taken with meals, prescribed for narrow indications or off-label use, and more effective for some people. Each of these characteristics in makeup, distribution, and use has the potential to benefit some people over others.

Development of Health Technologies

The cycle of innovation suggests that new drugs and technologies are first tried out on poor populations living around research institutions who then lose access to these innovations when they become part of standard care (Duff & Hollingshead 1968). Petryna (2009), for instance, showed how the outsourcing of clinical trials to Eastern European and Latin American countries exposes populations in these countries to experimental drugs, but these same populations may lose access when treatment saturation has been reached and the trials move to different shores. At the same time, when clinical trials are considered a last chance at a promising therapy, those with more resources advocate for inclusion in such trials (Epstein 1996, 2007).

Regulation of Health Technologies

Countries and states have regulated and approved different technologies and drugs and offer various forms of cost control, making some health technologies available to some populations with few restrictions and others impossible to obtain (Abraham 1995, Gardner et al. 2017). For instance, the controversy around BiDil, the first drug approved by the US Food and Drug Administration to treat heart failure that was specifically aimed at African Americans (Kahn 2004), invigorated the debate about race as a medical category.

Institutional Competition

Costly, advanced technologies serve as a way for hospitals to capture market share. Congruent with the notion of institutional isomorphism, a technological arms race follows from competition among comparable institutions. For complex gatekeeper technologies, Menchik (2017) has shown how clinicians at prestigious research hospitals compete for status, money, and prestige through the adoption of technologies. The result is a sorting of hospitals with different care philosophies, capacities, and technological capacities catering to different populations stratified by race and class (Abraham 1993, Reich 2014). Hospitals that disproportionately serve minority populations, for instance, face challenges in adopting health information technologies compared to well-resourced academic medical centers serving wealthier populations (Adler-Milstein et al. 2014).

Social Interaction

Diagnostic and treatment technologies are integral to the patient-doctor interaction, and therefore all the physician and patient attributes that produce treatment bias may be enhanced by the use of health technologies (Spencer & Grace 2016). Polonijo & Carpiano (2013) already mentioned the role of a user's knowledge about the technology and a clinician's prescription

practices as key explanatory factors for the differential effects of health technologies. As we elaborate in the discussion of digital technologies, health technologies can also fundamentally reconfigure the patient-doctor relationship itself.

Health Cultures

Lutfeý & Freese's (2007) comparative analysis of diabetes care in two clinics catering either to low-SES or to high-SES patients confirmed that at every juncture, those of higher SES benefit from technological innovations. The wealthy experience more continuity of care, flexible treatment schedules, and lower costs of compliance. The authors pointed out the compensatory inversion in which those with the highest chance of educating themselves about diabetes outside the clinic also receive the best educational resources in the clinic. In an ethnographic study, Gong (2019) also demonstrated that mental illness for the wealthy and the poor is treated differently, with the poor having more freedom because of a lack of therapies and the wealthy being strictly under monitoring and constraints in intensive programs.

Further complicating this set of relationships is the fact that technologies and their outcomes may also affect the availability of resources different groups bring to health. The feedback loops from health outcomes to fundamental causes, especially since health is itself a resource to be capitalized and commodified.

With this conceptual framework in mind, we can now evaluate how some existing and new technological developments impact health disparities.

KIDNEY DIALYSIS AND TRANSPLANTATION

One of the temptations of studying health technologies is to focus on the shiniest new toys and lose track of the older technological infrastructures that create path dependency for what is to come. Indeed, much of our relationship to health technologies could be characterized as technological sleepwalking (Winner 2014). Technologies create new conditions, patterns, and structure for human activity, which in turn engender an unnoticed new normal. The influence of established technologies in contemporary life can be easily underestimated. For instance, the artificial pacemaker, with its 300-year development, now occupies a mostly irreflexive place in standard treatment care to reduce cardiac mortality (Ward et al. 2013). Here we highlight two older technologies, kidney transplantation and dialysis, which have blended into the health-care infrastructure but still create path dependency for present-day health disparities.

Chronic kidney disease (CKD) affects approximately 15% of US adults or 37 million people. Since early stages of kidney disease have no symptoms, reduced kidney function can progress undetected, leading to end-stage renal disease (ESRD). In 2016, nearly 125,000 people in the United States started treatment for ESRD, over half a million Americans received dialysis treatment, more than 200,000 people lived with a kidney transplant, and around 16,000 kidney transplants were performed (CDC 2019).

The widespread routine use of dialysis and kidney transplantation arose during the second part of the twentieth century, when immunosuppression and tissue-typing advancements substantially reduced the risk of kidney rejection and successfully improved matching between donor and recipients and when dialysis treatment became a recommended therapy (Blagg 2007). Later, the passage of the amendment of the Social Security Act in 1972 helped to establish a unique infrastructure: Patients with CKD would receive Medicare coverage regardless of age. This inclusive, egalitarian policy is exceptional in the United States; no other patient group was, or presently is, eligible for universal health coverage.

Despite these implicit guarantees of equal access to optimal renal treatment, a robust literature indicates that this system of care creates disparities at nearly every juncture from diagnosis and assessment to treatment type, showcasing how the effects of technologies on health inequities are multiple, flexible, and institutionalized into every aspect of health care and social life. CKD and ESRD are characterized by marked differences in incidence; prevalence; and complications across gender, age, race/ethnicity, SES, and geographic boundaries. In fact, ESRD remains one of the most dramatic examples of racial/ethnic health inequities, with incidence rates for African Americans, American Indians, Alaskan Natives, Asians, Native Hawaiians, other Pacific Islanders, and Hispanics ranging from 1.5 to 3.9 times those of age-adjusted, non-Hispanic, White counterparts (Norris & Agodoa 2005). These inequalities impart especially deleterious effects among Black ESRD patients and persist when controlling for lower SES and lack of insurance (Hsu et al. 2003). These disparities are unlikely to be genetic; variations between racial/ethnic groups are modest at best and much smaller than variations within groups.

Racial disparities in pre-ESRD nephrology access have changed little in the last 20 years. Black patients are less likely to receive any pre-ESRD care, and once having started dialysis, Black patients are less likely to have met with a nephrologist 12 months prior. Lack of timely access to nephrology care is associated with suboptimal pre-ESRD nephrology care, poor preparation for the initiation of dialysis, and adverse clinical outcomes after the initiation of dialysis, including higher mortality rates (Norris et al. 2017). Once patients are referred to a nephrologist, racial/ethnic disparities persist in treatment type. In the United States, the preferred treatment option is usually kidney transplantation or at-home dialysis, while in-center dialysis is considered less desirable. However, Black ESRD patients are less likely than White patients to begin treatment involving either kidney transplant or at-home dialysis care (Norris et al. 2017).

Among patients who begin dialysis, racial minority patients are significantly less likely to be treated with home dialysis than White patients (US Ren. Data Syst. 2018), and Black patients who begin dialysis treatment at home are more likely to eventually transfer to in-center treatment in comparison to White patients (Mehrotra et al. 2016). Home dialysis offers patients with ESRD greater flexibility and independence. In contrast, the in-clinic dialysis treatment process requires patients to dedicate ample time to frequent clinic visits. These clinic visits can usually last 3 or 4 hours and occur 3 times a week, imposing limitations on patients' work and travel (Abraham 1993).

Dialysis treatment facilities also vary in quality. Dialysis facilities located in predominantly Black communities have higher mortality rates and are less likely to comply with performance targets (Norris et al. 2017, Rodriguez et al. 2007). Black patients are also less likely than White patients to attend a high-quality dialysis facility, even when controlling for neighborhood poverty and racial composition of the patient's neighborhood (Saunders et al. 2014). Among patients receiving dialysis, Black dialysis patients are more likely than White dialysis patients to wait longer to be placed on a kidney transplant waitlist. Longer time spent on dialysis is associated with significantly poorer patient survival and graft survival rates after transplantation (Joshi et al. 2013).

In comparison to dialysis, kidney transplant recipients typically experience substantial quality of life improvements. The mortality rate for transplant recipients is 48% to 82% lower than for those on dialysis, and with consistent use of immunosuppressant medication, a donor kidney can last for many years (Wolfe et al. 1999). However, racial disparities persist in access to kidney transplantation in all stages of the process, starting with referral (Norris & Nissenson 2008). Evidence suggests that disparities in access to kidney transplantation are partially related to disparities in assessment for transplant suitability (Young & Gaston 2000). Patients who are not assessed are less likely to be placed on the waiting list and less likely to receive a transplant. Black patients are among the least likely to be assessed for transplantation (around the time of dialysis

initiation) even after controlling for insurance type (Johansen et al. 2012), and this disparity is not evident among other racial/ethnic minority patient groups (Young & Gaston 2000). Research indicates that physicians are less likely to believe that transplantation improves survival for Black patients than for White patients (Ayanian et al. 2004). However, some preliminary scholarship on social networks suggests that informational social support among Black patients is correlated with waitlist placement. Black patients who had people in their social network with information about kidney transplantation were more likely to be placed on the kidney transplant waiting list regardless of the structure (density or strength) of their social network (Browne 2011).

Once patients are placed on the kidney transplant waiting list, racial and socioeconomic disparities in access to kidney transplantation exist in donor organ receipt (Hsu et al. 2003). Since the need for transplantable organs far exceeds the available supply, a nationwide priority system, the Kidney Allocation System, guides the distribution of organ donations. The current priority system employs a rank order list that considers many factors to allocate kidneys such as age of the recipient, blood type of donor and recipient, organ size, and distance of the recipient from the donor kidney. Historically, Black ESRD patients have experienced reduced access to the waiting list and longer waiting times to receive a transplant compared with White ESRD patients (Young & Gaston 2000). Black patients residing in rural neighborhoods are especially likely to be wait-listed and transplanted than Black patients residing in urban communities (Patzner et al. 2009).

Revisions to the allocation system have attempted to remediate these inequalities and improve outcomes. However, despite revisions, disparities persist in transplant receipt, especially between White and Black patients: Black ESRD patients are less than half as likely as similar non-Hispanic, White patients to receive kidney transplants. Although 37% of those undergoing dialysis are Black patients, Black patients receive only 25% of cadaveric kidneys and 14% of kidneys from living donors (Young & Gaston 2000). Black patients who do receive transplants remain on the transplant waiting list twice as long as non-Hispanic, White patients (1,185 versus 605 days) (Young & Gaston 2000). A frequently cited cause of this disparity, the differential access hypothesis, suggests that disparities are attributable to decreased availability of medically compatible living kidney donors within Black patients' kinship networks. However, Daw (2014) has shown that these racial disparities in transplantation are unlikely to be the result of network differences: Black transplant candidates are more likely to have access to suitable kin donors than White patients.

Finally, among patients who receive kidney transplants, sociodemographic disparities exist in health outcomes. These disparities in kidney transplant outcomes occur by age, gender, level of education, geography, and race/ethnicity. Male patients, older patients, unemployed patients, single patients, and patients with less education face poorer rates of graft survival. Overall, Black recipients experience worse graft function and shorter graft survival in comparison to White recipients. Furthermore, patients who live farther from transplant centers and in low-income neighborhoods have lower graft survival rates (Gordon et al. 2010). Research suggests that some nonimmunologic variables may play an important role, including the duration of pretransplantation dialysis, diabetes, and access to medical care. Yet, these mechanisms also include a combination of both population-based determinants (e.g., health literacy, residential segregation) and health service-based determinants (e.g., providers' health beliefs and behaviors) (Sue & Dhindsa 2006).

In sum, there is little doubt that kidney treatment is lifesaving for ESRD patients. The United States has created a unique, one-off system of universal insurance for patients with a specific disease category centered around two health technologies: dialysis and kidney transplantation. Yet, in spite of this universality and at every turn, White kidney patients benefit in ways that Black patients do not. There is not a single cause but a number of both distinct and intertwined, mutually reinforcing social mechanisms that produce these health disparities spanning the range

from health-care-specific issues such as institutional racism to broader inequities in social life, including residential segregation (Norris & Nissenson 2008).

PERSONALIZED MEDICINE

Unlike the well-established track record of kidney dialysis and transplantation, personalized medicine is still a science in the making, and the impact on health inequities remains undetermined. In the postgenomic era, stratified, personalized, and precision medicine aim to replace the one-size-fits-all approach to medical care with approaches tailored to the individual patient. This individualization often rests upon the patient's genetic makeup: Genetic sequencing may inform an individual's risk for developing various diseases and response to medications (Prainsack 2017). Pharmacogenomics, for instance, uses genomic findings as a basis for recommending drugs to which the patient is likely to respond. Unlike the earlier understanding of personalizing medicine as engaging with the social needs of patients (Tutton 2012), personalized medicine involves an individualization of risk with an implied responsibility to optimize one's health (Rose 2007).

The notion of gene worlds draws attention to the uneven distribution of genetic technologies and knowledge across diseases, populations, and geographies with inequitable consequences (Timmermans & Shostak 2016). Some diseases have turned genetic in the sense that they are now understood primarily through a genetic lens, and entire disease taxonomies have been molecularized (Paul 1997). And similar to the reliance on forensic DNA databases in the criminal justice system, some populations are more likely to see their genomes sequenced and included in reference databases and biobanks. Genome-wide association studies (GWASs), for instance, aim to systematically compare genetic data derived from individuals with and without a particular disease to identify genetic variants that are associated with the disease under study. Minority populations are often underrepresented in GWASs, potentially skewing the interpretations in ways that can lead to misdiagnosis and perhaps contribute to global health inequities if the research leads to clinically relevant knowledge. Consequently, minority rights and patient groups advocate to have their conditions included in research endeavors (Epstein 2007, Gibbon et al. 2018). Yet, including these populations risks racial and ethnic stigmatization if certain groups are associated with genetic risk profiles (Fullwiley 2007, Lewontin 2001). De Vries et al. (2012) argued that the risk for stigmatization is greatest when the minority groups are already stigmatized or the genomic information has normative implications (e.g., genomic information reflecting back on sexual behavior).

In an early prediction about the impact of genomics on culture, anthropologist Paul Rabinow (1992) argued that traditional social classification such as gender and race will lose salience as a basis for group formation and will be transformed and joined by categories based on genetic markers, a process he called biosociality. Drawing from Foucault, this transformation signified a broader biopolitical shift from normalizing to optimizing the health of populations. The prediction proved partly true. Navon (2011) refined biosociality with the notion of genomic designation, which captures how new disease syndromes emerge based largely on genetic mutations without necessarily a phenotype of shared symptoms. For instance, the discovery of a small missing piece in the middle of chromosome 22 led to the designation of 22q11.2 Deletion Syndrome. Despite the fact that features of the syndrome vary widely (affecting almost any part of the body), patients with 22q11.2 Deletion Syndrome formed patient groups, and the mutation received intense scientific study.

Yet, Rabinow's (1992) intuition that genomic sequencing would displace gender and race as social categorizations was also partly misguided. Genomics, as Roberts (2011), Duster (1990), and others have argued, has become the new race science, with self-reported race categories widely used as rough proxies for allele and haplotype variation in patients and with scientists relying

on nonscientific racial and ethnic categories (Fullwiley 2007). In light of a history of eugenics (Comfort 2012), age-old assumptions about racial differences and segregationist and colonial histories permeate how geneticists conceptualize race, delineate subpopulations, sample data, implement analytical algorithms, and rely on evolutionary theory to theorize and report ethnic and race-based differences (Morning 2012). Phelan et al. (2013) used a vignette study to test Duster's (1990) assertion that reports of specific genetic bases of disease, because they are presented as objective facts, may heighten public belief in more pervasive racial differences. They showed that a news story vignette reporting a specific racial difference in genetic risk for heart attacks produces significantly greater belief in essential racial differences than do alternative vignettes portraying race as a social construction or a no-vignette condition. "Rather than gross characteristics such as intelligence or personality," Rabinow & Rose (2006, p. 208) suggested that genomics as the anchor of the new biopolitics will target individualized interventions according to a vitality logic. Au contraire, Richardson (2011) showed that novel research on the link between the genomic basis of race and IQ research has given a discredited research area some legitimacy in the reconstituted field of evolutionary cognitive genetics (see also Panofsky 2014).

How do these genomic data make a difference in the clinic? Regardless of the link to health inequities, researchers have found that in spite of the so-called *genohype* of fundamental transformations and genetic essentialism (Freese & Shostak 2009), the availability of genetic information is not deterministic for diagnosis or treatment (Weiner et al. 2017). Instead, the reception of genomic findings depends on the seriousness of the disease and how the findings confirm what people already thought or feared. Thus, clinicians up- or downgrade variants of clinical uncertainty depending on how they see these mutations fitting the patient's phenotype (Pilnick 2004, Timmermans & Stivers 2017). Patients, in turn, filter the results based on how they match their own understanding of risk and symptoms running in their families. Genetic susceptibility to diseases with devastating prognoses is often taken more seriously than risk factors for more benign conditions (Weiner 2011). But even there, experience with disease and disability may trump genetic knowledge (Raspberry & Skinner 2011). While genetic information may spill over beyond the patient and put recipients in a holding pattern as patients in waiting (Timmermans & Buchbinder 2010), families resist and accommodate genetic knowledge (Rapp 2000).

More specifically to health inequities, anthropologists Hunt & Kreiner (2013) interviewed primary care physicians about their expectations for personalized medicine and found that the majority of physicians would decide on genetic tests based on family history and presumed racial risk factors. These physicians mentioned that they had been taught to prescribe antihypertensive drugs differently for their African American patients [this remains controversial; see Kahn (2004)]. Hunt & Kreiner (2013, p. 228) concluded that personalized medicine "can be converted into *carte blanche* for practicing racialized medicine." Research in disability studies has warned that genomic technologies may be appropriated in prenatal testing for eugenic purposes (Shakespeare 2005). Wealthy and highly educated parents of children with disabilities may also marshal genomic test results to convince school systems to provide additional services (Stivers & Timmermans 2017).

As Skinner (2006) pointed out, however, it is impossible to calculate the extent to which the clinical application of genomic information has introduced or exacerbated measurable health inequities. We know, for instance, that while genome-targeted therapies and immunotherapy helped drive down cancer mortality rates in recent years, much bigger drops will follow from eliminating socioeconomic disparities (Prasad 2020). While the postgenomic era offers many disturbing instances of locating genetic risks among racial groups and reincarnations of biological racism, such essentializing moves also receive a heavy backlash, with public denouncements, political and community pushback (Tallbear 2013), and exposés from social scientists (Panofsky 2014). At the same time, enthusiasm for personalized medicine may also be a threat to health equity, with investment

in genomic research crowding out funding for social determinants of health disparities (Arcaya & Figueroa 2017).

DIGITAL HEALTH

In the field of eHealth or digital health, technological innovations, including health information systems, electronic patient records, wireless mobile digital devices, wearable biosensors, telemedicine, social media sites, and electronic support groups, are ubiquitous. Such technologies come with high expectations of improving communication between health-care providers and patients or, alternatively, of sustaining lay health promotion. Digital technologies also promise to reduce health-care costs and to erase the health knowledge disparity between providers and patients by making health information accessible at everyone's fingertips. Digital health signifies an expansion from medicine to health. In the era of lifestyle diseases such as overeating, under-exercising, stressing, and smoking, everyone is constantly at risk of sickness, and staying healthy permeates everyday activities (Rosenberg 2007). Consequently, entire industries have sprung up to track, calculate, mine, visualize, and share health data with Internet-connected wearable health monitoring devices (Schüll 2016).

This is a rapidly moving area of heterogeneous and multifaceted innovations, where more research attention has been focused on keeping up with the developments within digital health than with their effects on health outcomes, not to mention their role in health disparities. The Pew Research Center's Internet and American Life project found in 2012 that 59% of adults went online for health information in the previous year, and 35% went to diagnose themselves (Fox & Duggan 2013). One-quarter of American 13- to 18-year-olds reported using health-related apps and/or wearable devices (Wartella et al. 2016). In spite of fears among clinicians that Dr. Google is replacing the clinic visit, the use of online resources complements rather than substitutes for clinicians' expertise. The Pew Research Center study found that 53% of online diagnosers talked with a clinician about what they found, and 41% had their condition validated by a clinician (Fox & Duggan 2013). Other studies have confirmed that clinicians remain the main source of health information and that, especially during health crises, people rely on health information from clinicians rather than the Internet (Gage & Panagakis 2012, Miller & West 2009). The Pew Research Center study also showed that 16% of adults have gone online in the past year to find others who share the same health concerns (Barker 2008, Fox & Duggan 2013, Raz et al. 2018). Already in 2012, half of smartphone owners used their devices to get health information, and 20% relied on health apps (Fox & Duggan 2012). A systematic review of 12- to 25-year-olds identified only two empirical studies that measured the health-related effects of using nutritional and/or physical activity apps (Dute et al. 2016). Some of these apps may motivate weight reduction, but other nonrandomized interventions did not show significant differences in nutrition or physical activity.

Does digital health reinforce and introduce new inequities, or will it instead reduce inequality by lowering the cost of information and enhancing health among vulnerable populations (DiMaggio et al. 2001)? Digital inequity has been recognized as a distinct form of social inequity: Those who engage most in digitally mediated life enjoy advantages over their digitally disadvantaged counterparts (Robinson et al. 2015). We know that women, young people, White adults, those with at least a college degree, and those in households earning more than \$75,000 are more likely to peruse health information online (Ayers & Kronenfeld 2007, Fox & Duggan 2013, Kontos et al. 2014, Zhao 2009). Differential engagement with online health data combined with different health lifestyles may reinforce health inequities (Hale 2013). Yet, while digital engagement in health is structured by class, race, and gender, digitally acquired knowledge may also give some people of traditionally disadvantaged groups—such as minority youth—an edge to overcome their lack of cultural health capital (Shim 2010, Zhao 2009). The effects of digital health are thus

multifaceted: Such technologies may reinforce existing social inequalities by carrying preexisting differences in human capital into online settings; they can create new lines of divisions based on digital engagements; or, with targeted interventions (Anderson-Lewis et al. 2018), they can help some groups decrease disparities.

A fundamental structural inequity persists between those targeted for data collection and the companies who collect, transfer, store, and mine large quantities of data in order to monetize them. Apps and online platforms, including those used for genetic testing, monetize proprietary health information to tech firms, pharmaceutical companies, hospitals, health insurers, advertisers, credit rating companies, and medical device makers (Hogle 2016, Lupton 2014). As with genomic information, such technologies that scrape health data may either systematically exclude underrepresented groups or exploit their data for applications that are unlikely to benefit those providing the data.

The literature suggests several social mechanisms by which digital health technologies may accelerate health inequities. Many digital health solutions are patient facing, shifting responsibility for preventative health onto patients. In contrast to the notion that digital health technologies “position the neoliberal self as a responsible citizen, willing and able to take care of her or his self-interest and welfare” (Lupton 2013, p. 263), Schüll (2016) argued that datafication rests on a behavioral nudge—as popularized by behavioral economists Thaler and Sunstein’s vision of libertarian paternalism—for healthy lifestyles by reframing rather than restraining choices. Instead of self-responsibility, the underlying vision for humanity is one of freedom of choice but weakness to follow through, valuing one’s choices but delegating responsibility to external technologies supplementing behavior with micronudges. Studies show, however, that these same micronudges may lead to negative feelings when people miss targets (Goodyear et al. 2017).

Secondly, because the Internet lowers the cost of generating and disseminating information, some studies also start to examine the accuracy of information available online, implying that some populations may be more vulnerable to misinformation. Research has documented some of the extent of misinformation, but less is known about its (differential) reception. A network analysis of 2.5 million tweets collected over an 8-month period showed that the main purveyors of diabetes information are a mixture of stock-listed firms; public, civil, and grassroots organizations; and individuals who have experience with diabetes as patients and caregivers. The authors noted that it is “difficult for Twitter users to be ‘informed citizens’ and discern legitimate from misleading or discredited information, or a bona-fide health expert from a social-media expert, or a marketer with business motivations from a marketer with public health ones” (Beguerisse-Diaz et al. 2017, p. 20). More deliberate fake health news and misinformation have proliferated in the areas of vaccination, virus infections (e.g., Zika, Ebola), cancer, and cardiovascular diseases, where online communities favor conspiracy theories with discussions that revolve around rhetorical and personal arguments of fear and distrust (Wang et al. 2019). The misleading portrayal of tobacco’s health consequences as promulgated by the tobacco industry introduces positivity toward smoking (Albarracin et al. 2018). Little is known, however, about whether some populations are more susceptible to Internet misinformation, as either producers or consumers.

While there is little doubt that digital health technologies are widely used, it is difficult to disentangle digital technologies’ independent effects on social inequities, because these technologies are so intertwined with every aspect of wellness and health care, many of them take off quickly and widely, and they may have few observable, direct health effects.

CONCLUSION

Health technologies will, at best, explain only part of the social disparities in population mortality and morbidity. Researchers have drawn attention to social determinants as not only perpetuating

health inequities but also erasing some of the gains made with technical interventions (e.g., McKinlay & McKinlay 1977). Yet, besides their ubiquity in medical care, health technologies are central in many population-based public health initiatives, and these technologies have been increasingly embraced as part of everyday wellness and life enhancement routines. This overview demonstrates a recurring technology population health paradox: Taken together, health technologies are health promoting, but they also tend to exacerbate health disparities, because people with resources are able to take advantage of these technologies sooner and more effectively. In spite of the hopes and fears that new generations of technologies will revolutionize health, it is unclear that all technologies have measurable health benefits. Morbidity and mortality outcomes and disparities are well documented for kidney dialysis and transplantation, but the clinical actionability of genomic science remains in the early stages, and there seems to be lots of variation (and little research) on the population effects of digital health.

The conceptual framework we advanced to study the health effects of technologies draws attention to the specificity of individual technologies: the design aspects of technologies, their dissemination and availability, and the actual use of the technologies. Each one of these elements can be influenced by remote decisions such as a regulatory environment and market conditions, by more proximate events such as a clinician prescribing a technology to some people but not to others, or by an intended user deciding to ration medications as a cost-saving strategy. Technologies that are universally available and require little human input are likely more egalitarian than those that require any kind of resources to make the technology work.

This framework is theoretically compatible with Marxist theories focusing on the profit motives in the overselling of technologies to mystify the roots of ineffective practices: It is a matter of mapping those who benefit financially from health technologies (Waitzkin 2000). In the context of global health, Paul Farmer (2005) and others, for instance, have demonstrated that entire health-care systems lack access to basic, lifesaving treatments that are available elsewhere. These transnational inequities produce preventable deaths and structural suffering. The model connects with a social constructivist approach that focuses on how technologies get settled and used (Bijker et al. 1989). Finally, it is also compatible with an actor-network approach to the study of technology focusing on how technologies act in shifting configurations of networks (Latour & Venn 2002). For those theories enamored with technology-driven shifts in morality, social relationships, and subjectivity, the model cuts sharply to the chase: Do health technologies benefit health, and if so, for whom? Underuse of health technologies for some, overuse for others, and misuse for many lead to an erosion of the life-enhancing and lifesaving potential of these technologies.

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