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Technological Innovations and Social Inequalities in Global Health

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Abstract

Social inequalities in health have been observed in all countries with available data, and they are on the rise particularly in advanced welfare states. A number of theories have been proposed to explain this growth in health inequalities. This chapter argues that innovation could play a significant role. Well-developed welfare states are also characterized by being technologically advanced. As technological innovations become an increasingly important form of socioeconomic capital in modern society, it is important to understand the ways in which these resources are contributing to health disparities. However, current research has done little to systematically conceptualize or empirically test the dominant mechanisms through which technological innovations may be influencing the persistence and growth of social inequalities in health. This chapter presents a conceptual model, which demonstrates how technological innovations in health appear to have the power to either increase or decrease inequalities. However, the direction and magnitude of this relationship is shaped by a number of mechanisms at various levels of the social spectrum, which are dependent on important technological and sociopolitical contextual factors. Theoretical and empirical research supporting this model are also briefly presented. The implications of the model suggest that technological innovations are important mediators of mechanisms that influence the (re)production of systematic socioeconomic inequalities in health. These implications are then discussed in relation to issues of global health and how they may relate to low-, medium-, and high-income countries.

Keywords Social inequality - Technology - Innovation - Health disparities

Introduction

Social Inequalities and Health: A Growing Global Burden

The first resource we are provided in our lives is health. Good health is of vital importance from early childhood, not only because it helps us live through our first years but also because it helps us fulfill our potential throughout our lives. At the same time, good population health is important for countries in their efforts to obtain sustainable societies. Consequently, health is a fundamental resource for people and for the countries in which they live.

It is therefore good news that the world population is living longer and healthier and that progress has been made in the fight against major drivers of ill health and death. Since 1990, we have seen substantial progress in reducing the burden of key global health challenges. For example, the global age-standardized death rate due to communicable, maternal, neonatal, and nutritional causes has decreased from 281 deaths per 100.000 population in 1990 to 144 in 2017 (Besnier and Eikemo *2019*).

Although all people have the same fundamental right to health (UNICEF, World Health Organization, & International Conference on Primary Health Care), how you experience this right differs between countries and regions. If you are born in a poor country, you are more likely to live in poorer health and die earlier than if you are born in a wealthy country. If you are born into a poor family in a poor neighborhood, then the risk of dying before the age of 5 would be higher for you than for others born in more wealthy families and neighborhoods – regardless of whether you live in a poor country or in a rich country. This is the root of inequality. Inequality has no borders. It kills in all countries.

Despite the average progress of global health, wide inequalities in health persist both between and within countries and global regions. In 2013, developing regions had a maternal mortality ratio 14 times higher than developed regions (UNDESA *2015*), and in 2015, 99% of all maternal deaths occurred in low- and middle-income countries (LMICs) (World Health Organization *2015*). At the same time, socioeconomic status (SES) is affecting people's longevity within countries. For example, under-5 mortality is 1.7 times higher among rural children than among urban ones and 2.8 times higher among children whose mothers had no formal education.

This is what we refer to as social inequalities in health. They exist for all preventable conditions and preventable causes of death, and they are therefore the biggest public health challenge that the world is facing. They have been observed in all countries with available data, and they are increasing in many countries. The systematic existence of health inequalities between different socioeconomic groups is extensively documented particularly in Western Europe (Mackenbach et al. *2008*) and North America (Robert Wood Johnson Foundation Commission to Build a Healthier America *2009*) but also in the rest of the world (Marmot et al. *2008*). These health inequalities begin to emerge during childhood, and, despite improvements in infant and under the age of 5 mortality rates in recent decades, significant inequalities in these rates exist within and between countries.

It is estimated that in the EU alone, more than 700.000 avoidable deaths per year are due to health inequalities, which amounts to €141 billion in economic losses annually (Murtin et al. *2017*). However, social inequalities in health are not only costly for our societies in terms of lower productivity and higher healthcare costs (Mackenbach et al. *2016*). They are also widely considered to be unfair, unjust, and unnecessary (Whitehead *1991*).

Research has indicated that social and economic factors embedded in societal structures are key in understanding the emergence and distribution of these inequalities (WHO Commission on Social

Determinants of Health *2008*): the social determinants of health. For example, we know that income inequality and income poverty are closely linked to the problem of health inequality; we know that a good childhood impacts on the entire life cycle; we know that education is an important source of knowledge, work, income and social inclusion; we know that a health protective work environment should provide a good physical and psychosocial working environment, as well as financial security; we know that harmful health habits are more common in lower socioeconomic groups, which in turn stem from differences in social, economic, and environmental living conditions; and we also know that the health services can reduce social inequalities in health by prioritizing the most needy (Arntzen et al. *2019*).

Therefore, we do have tools to reduce health inequalities and many countries have therefore initiated attempts to reduce health inequalities. However, this remains a challenge as we are in constant need of better evidence concerning the identification of policies, institutional conditions, and interventions with the greatest impact for reducing them. As such, there is a need to expand the knowledge base of measures, initiatives, and interventions that may help reduce social inequalities in health.

In this chapter, we introduce and discuss the relevance of a new social determinant: technological innovations. The fact that social inequalities in health are widening in the most advanced societies with well-developed welfare systems have long been regarded as a public health puzzle (Mackenbach *2012*). However, modern societies are characterized by the implementation of new technologies, which can help prevent diseases and promote health. Increasingly, technologies are necessary prerequisites for gaining access to, and making effective use of, many of societies services as well as social, cultural, and economic advantages. Users are therefore required to have necessary knowledge and economic resources. Inequalities in access and use of new technologies may provide a feasible explanation of the public health paradox, as this chapter will demonstrate. If countries are being punished for successfully pursuing technological progress, then we may have identified yet another important area of intervention to reduce health inequalities. Understanding how these technologies influence the complex relationship between socioeconomic status and health, however, is both poorly addressed by relevant research and a necessary precondition for understanding their importance in providing and maintaining health for all in modern societies.

Technology and Social Inequality: A Conceptual Model

In a similar vein to other leading scholars, Krieger (*2008*) has argued that conceptual models "are crucial for theorizing, depicting and explaining population distributions of health inequalities." *The Health Inequality and Technology model* (HEAL-TecH model) presented in Fig. 1 is such as model (Weiss *2020* doctoral thesis). It is a conceptual model for understanding how technological innovations may influence health inequalities. The model sets a foundation for further explaining and understanding the influence of technological innovations on social inequalities in health in our societies.

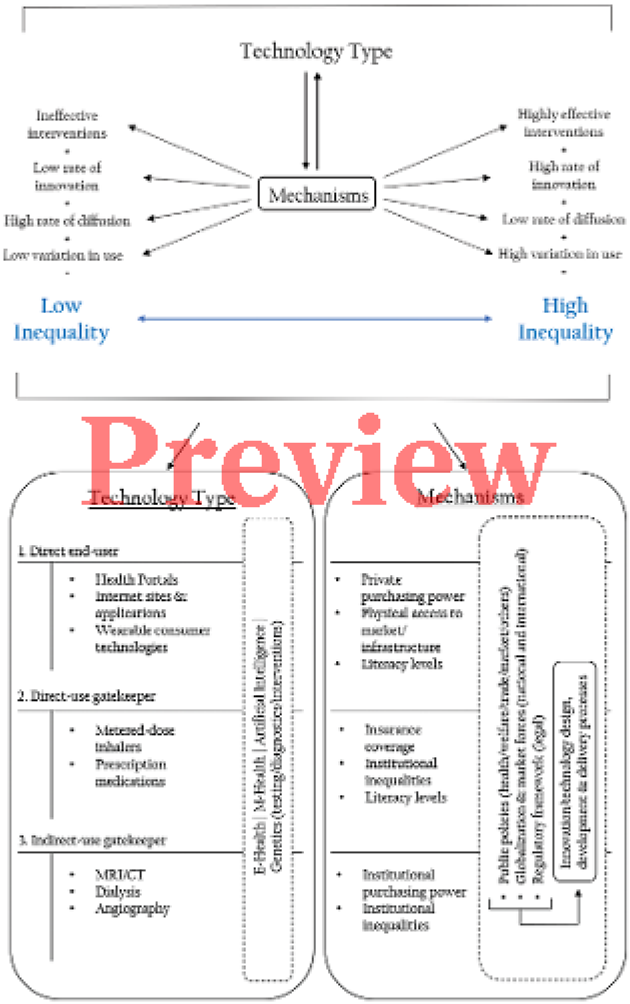

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Fig. 1

"HEAL-TecH" – a conceptual model for understanding how technological innovations may influence health inequalities

However, before digging deeper into the inner workings of the HEAL-TecH model, it would be helpful to define technological innovations in the current context, as many interpretations of technological innovations exist in the literature. In this case, various interdisciplinary definitions of technology and a broad understanding of public health have contributed to defining technological innovations as they relate to contexts of public health and social inequality. A full discussion of the conceptual integration of related work in the fields of medical technologies, innovation, and technology resulting in the current contextual understanding of technological innovations is unfortunately outside the scope of this chapter. However, the results have led to the following working definition, which is reflected in the research that has led to developing the HEAL-TecH model in Fig. 1. Technological innovations, in this case, are understood as:

Definition: "Technological Innovation in Health"

A design for instrumental action that reduces the uncertainty in the cause-effect relationship involved in achieving a desired outcome, which: (1) includes both a hardware and software component, (2) is perceived as new by an individual or other unit of adoption, and (3) which emerges in contexts of, and related to, public health.

Let's break down this somewhat complex definition to somewhat simpler terms. The first sentence in the above definition, adopted from research on the diffusion of innovations (Rogers *2003*), defines technology as a tool that can allow a more predictable outcome to the solution of a particular problem. The second part of the definition differentiates between technologies that are purely knowledge-based by explicitly stating that a technology must, in addition to new knowledge created by the tool, also have a physical component. The third part of the definition broadly incorporates an understanding of innovation as anything that experienced as new. This broad understanding is purposeful, as innovations do not necessarily have to be new from an objective standpoint but can also be new from a subjective standpoint. The last part of the definition incorporates a, again purposeful, broad association with contexts of health. The definition allows for the incorporation of technological innovations that are traditionally understood as important tools of public health, such as MRI machines or AIDS medications, but also leaves room for technological innovations that are non-traditional in nature, such as wearables in the form of watches, patches, or even implants. This is particularly important moving forward as technological innovations in health, in an increasingly technological society, are increasingly found outside of the traditional boundaries of health care and in many cases have important implications for both public health and social inequalities (as we will see later in this chapter), such as artificial intelligence and biotechnologies.

We now turn the attention to a more thorough explanation of the model depicted in Fig. 1. This model presents, first, a pathway-dependent spectrum of inequality and, second, a collection of mechanisms reinforcing the power and influence of these pathways on observed levels of inequalities. Observed levels of inequalities, spanning from relatively low to relatively high across the spectrum, are a result of the aggregate influence of several dominant characteristics determining the position of a technology in society. These characteristics include the effectiveness of the technology-dependent intervention, the rate of relevant technological innovation, the rate of relevant technological diffusion, and the amount of SES-based variation in the use of these technologies. This condensed explanation of the model is quite complex and conceptual, so let us use an example to simplify and further illustrate this explanation, before examining each part of the model in greater detail. Let us consider an innovative monitoring device, designed to be used at home by diabetes patients to measure and monitor their blood glucose levels. In the right hands, this current technology is very effective at helping its user reduce instability in blood glucose levels (which is very good news for a person with diabetes) due to its accuracy, reliability, and frequency of measurements, allowing for precise self-administration of insulin (which is directly used to keep blood glucose levels regular). As reflected in the model, this level of effectiveness has the potential to promote inequalities (as explained below). The technology in our example also has a low rate of innovation. In other words, due to policy and regulatory barriers that introduce prohibitively high investment costs for the development of alternatives, very few competing technologies are available, and any competing technology is years away. This has the potential to promote relatively low inequalities. Now, due to this technology being covered by very few insurance policies, and a relatively high, prohibitive investment cost by users, who are mostly required to purchase this device on the private market, diffusion rates are very low. In other words, there are relatively few users of this device, and the rate of new users, particularly those in completely new user groups, is very low. This low rate of diffusion, for reasons that may or may not be apparent, promotes inequalities, somewhat offsetting the reductional effect of low innovation. And finally, relatively large variations in the ways in which this device is used again promote high inequalities, this time between users. This is due to the complexity of the device – which has many functions that are also dependent on the users' ability to exploit the use of complimentary computer-based software – and its ability to be modified by users to increase its effectiveness. In this case, a user's level of "literacy," or relevant and usable knowledge or competence, highly influences the effectiveness of the device. So, two users of the same device may experience very different results from using the device even if they both have the same relative need for the device's benefits. In our example above, this innovative glucose monitoring device is likely to be associated with relatively high inequalities, due to a combination of high effectiveness, a low rate of diffusion and high variation in use patterns. However, this same technology, regardless of its effectiveness, could very well be associated with low inequalities if, for example, environmental conditions increased its rate of diffusion, introducing a much larger number of users across demographic groups, as well as simplified the device's functionality, flattening its effective usability across users. With similar examples in mind, let us examine each part of the model in greater detail to better understand why each of these characteristics influences inequalities in the suggested direction.

In regard to the effectiveness of a technology-dependent intervention, its importance lies in its ability to determine relative individual advantage. Empirical research has illustrated this effect, demonstrating that highly effective interventions are associated with growing inequalities (Phelan and Link *2013*). A technological innovation with little positive effect on relevant outcomes in health has, therefore, little effect on inequalities. Increasing the effectiveness of a technology-dependent intervention increases the probability that this intervention (or technology) will (re)produce or increase SES-based inequalities. This is due to the early and often increased access, adoption, and exploitation of these interventions by high SES groups, contributing to a concentration of increased relative advantage for users, particularly early users.

The rate of relevant innovation also influences the potential for a particular technology to (re)produce relevant inequalities. Although low rates of relevant innovation, in which an innovative technology and its productive outcomes stand relatively unchallenged, does not guarantee low inequalities, achieving low inequalities in an environment where new technologies are continually being challenged or replaced is unlikely. This is due in part to the social disruption (which can be compared to Bourdieu's idea of "hysteresis") resulting from high rates of innovation, where new positions of power or advantage are continually created. A high rate of innovation increases relative advantage for high SES groups due to a rapid rate of accumulating benefits only available as a result of early access and adoption. In other words, in an environment with low rates of innovation, the potential for accumulating relative advantage is low since the advantages from these innovations are given time to diffuse across social strata.

Regardless of an environment with low rates of innovation, however, diffusion rates have a powerful effect in determining the resulting magnitude of inequalities. In contrast to rates of innovation, slow rates of diffusion allow relative advantage to be held for longer periods of time and, therefore, promote the (re)production of inequalities. An innovation that diffuses quickly, however, distributes its effects rapidly across social strata, and, therefore, potentially large inequalities tend to survive for only short periods of time. However, rapid (and full) diffusion is not enough to guarantee low rates of inequalities. High rates of diffusion may mask important inequalities in SES-based use patterns. This is particularly significant when one considers that these inequalities tend to be subtler and often more difficult to recognize and measure when compared to inequalities in access, therefore increasing the likelihood that these inequalities are unrecognized or misrecognized as natural inequalities rather than sociopolitically constructed imbalances in status-related advantage.

Furthermore, some have argued that complex technologies are generally more likely to promote higher relative advantage for groups of users that are more able, and likely, to exploit the potential effects of these sometimes difficult to use, and often difficult to access, technologies (see, e.g., Goldman and Lakdawalla (*2005*)). Simple technologies, it is argued, instead reduce inequalities due to their effect on reducing the relative input required to accrue advantages. However, a perspective focused on *variations in use* (rather than merely on complexity) not only incorporates but also more broadly represents relative complexity in relevant contexts. This is because inequalities associated with variations in technological complexity are represented by the ways in which technologies are used differently by various groups (i.e., rates of effective consumption). In other words, in regard to inequalities, it is between-group variations in use that are important for outcomes, not the complexity of a technological innovations (although complexity may drive variations in use). Moreover, understanding the development of inequalities as a product of their complexity (or simplicity) results in an oversimplification of the relationship between technological innovations and inequalities. A simple technology may, for example, reduce SES-based inequalities in the ways in which a technology is used and therefore the advantages acquired from that technology. However, as the HEAL-TecH model in Fig. 1 illustrates, it is still possible to imagine a simple technology: (1) that is slower to diffuse than a more complex technology – due to, for example, less developed diffusion networks and weaker change-agencies (although the opposite is likely more often true); (2) that is more effective than a complex technology (although one may expect the opposite to be more often the case); or (3) that finds itself in a high-innovation environment (which is likely the case, as environments with simple technologies provide considerably more opportunity for the development and implementation of more complex technological innovations). In any one of these above scenarios, the relative simplicity of the technological innovation may be outcompeted by other characteristics that, in sum, (re)produce (rather than reduce) inequalities.

Similarly, the constant competition between these various characteristics is an important consideration. Their relative strength is not static. One could, for example, have a situation where inequalities are similar but where the strength and distribution of these characteristics is vastly different. An environment with highly effective interventions and high rates of innovation, for example, but high rates of diffusion and low variation in use may exhibit similar inequalities to an environment with poorly effective interventions and low rates of innovation, but low rates of diffusion and high levels of variation in use. Although the observable outcomes would be similar, the strength of the environmental characteristics (re)producing these outcomes would be vastly, and importantly, different. In other words, these characteristics are constantly pushing and pulling on one another to produce existing levels of inequalities and have the ability to both reinforce or counteract the strength of one another. The relative weight of these shifting environmental characteristics, moreover, depends on important factors related to the type of technology and the relevant mechanisms associated with that particular technology type.

Type of technology importantly influences the production of mechanisms, and their relative strength and composition, which are specific to that technology type and, in turn, most influential in (re)producing the inequalities that are either stimulated or moderated by the relative strength of the characteristics discussed above. In a model presented by Weiss et al. (*2018*), relevant technologies are divided into three categories: direct end-user technologies (type 1), direct-use gatekeeper technologies (type 2), and indirect-use gatekeeper technologies (type 3). The central premise of this categorization lies in its ability to illustrate and represent technologies based on how they are both accessed and used by “end-users,” or the individual(s) that directly benefits from the technology. This categorization represents a spectrum of technologies ranging from “accessed and used directly by the end-user” (direct-end-user technology) to “accessed and used by someone other than the end-user” (indirect-use gatekeeper technology). Where a technological innovation is positioned along this spectrum determines what mechanisms will most powerfully influence the (re)production (or reduction) of associated inequalities. A direct end-user technology (such as an internet-based application), for example, would influence, and be influenced by, mechanisms closest to the end-user (e.g., private purchasing power). An indirect-use gatekeeper technology (such as an MRI machine), in contrast, would influence, and be influenced by, mechanisms farther from the end-user (e.g., institutional purchasing power) and closer to the institutions through which end-users typically access and use these technologies.

The “mechanisms” in the model, importantly, provide a pathway linking technology with the environmental characteristics that collectively determine the level of inequalities in a social space; therefore it is these mechanisms which are largely responsible for (re)producing the conditions that (re)produce inequality. These mechanisms are a natural product of the collective structure of the social space and in many cases exist regardless of technologies. Technologies, in other words, are not a mechanism in and of themselves that (re)produce inequalities, but these technologies, and their type, stimulate the (re)production of these mechanisms across society, influencing the strength of associated inequalities.

Diabetes technologies can again offer an interesting example (Weiss et al. *2020*). Technologies such as insulin injection devices and glucose monitors can be both direct end-user technologies (many of these technologies can be freely purchased by individuals – such as the FreeStyle Libre glucose monitor) and direct-use gatekeeper technologies (many of these technologies are also, or solely, available as prescriptions). Whether or not these technologies are classified as “direct end-user” or “direct-use gatekeeper” technologies are dependent on circumstances largely a result of health system and market regulation policies, where some of these technologies may simultaneously be classified under both technology types (i.e., offered as a prescription technology covered by insurance as well as available for private purchase). However, the mechanisms that regulate or stimulate the strength of inequalities vary depending on the type of technology. When these technologies are available as direct end-user technologies, we would expect that intermediary mechanisms such as private purchasing power (individual or household economic capital) and physical access to an available market (i.e., whether or not it is possible for individuals to purchase these technologies and necessary associated technologies for sustained maintenance and use) would be highly influential in driving inequalities. In cases where these technologies are available as direct-use gatekeeper technologies, we would expect intermediary mechanisms such as insurance coverage (whether or not this is available to individuals of various SES) and institutional inequalities (where inequalities in access to technologies and their available advantages are (re)produced within healthcare institutions) to be highly influential in driving inequalities. We would, furthermore, expect that, in both cases, literacy levels (i.e., SES-based variations in relevant knowledge), particularly health literacy, would be important intermediary mechanisms responsible for the strength of existing inequalities.

Interestingly, the intermediary mechanisms in the HEAL-TecH model in Fig. 1 are a reflection of Pierre Bourdieu’s well-respected and often popularized social, economic, and cultural forms of capital. Institutional and individual purchasing power as well as physical access to markets and insurance coverage, for example, correspond well with forms of economic (i.e., material) capital. Literacy levels and institutional inequalities, in contrast, correspond well with forms of capital more symbolic in nature (i.e., social and cultural capital). Noting the relevancy of these mechanisms to Bourdieu’s forms of capital highlights the “fundamental” nature of their existence, persistence, and influence in the social space, lending credibility to a relevant “theory of practice.”

In addition to these intermediary mechanisms, however, a broad range of overarching systemic mechanisms are also highly influential in moderating relevant inequalities. These are mechanisms that, compared to the intermediary mechanisms discussed above, are less proximal to the individual and less confined to particular technology types but highly influential in structuring the larger social space in which these intermediary mechanisms exist. While intermediary mechanisms could be thought of as meso-level, these structural mechanisms embody the macro-level. Examples of these mechanisms include public policies (in health and welfare, trade and markets, etc.), globalization and market forces (both nationally and internationally), and regulatory (i.e., legal) frameworks, such as those reflected in many of the dominant models presented in Krieger (*2008*). The importance of these macro-level mechanisms lies in their general influence over larger societal processes across the sociopolitical spectrum, creating a foundation for the (re)production of social, political, and economic structures.

The powerful nature of these mechanisms, therefore, also shapes the processes that lead to the production of technological innovations. In other words, these mechanisms (that reproduce the conditions that moderate or stimulate inequalities) are not merely influenced by the types of technologies in society. These mechanisms also influence the types of technologies that are produced across society (suggesting a multidirectional, rather than unidirectional, relationship). For example, prescription medications (a type 2 technology) may influence the (re)production of inequalities through mediating mechanisms such as purchasing power or public health policies, but these mechanisms will, likewise, influence the diversity and availability of medications on national and international markets. Therefore, it is valuable to think of the relationship between relevant mechanistic forces and technology type as codependent, cooperatively creating and shaping the dominant characteristics that represent the environment in which they both exist. The product of this relationship, in turn, determines the collective composition of the environmental characteristics that directly influence the strength of existing inequalities.

Theoretical Development of a Grander Theory

Major sociological and social epidemiological theories have largely supported and informed the empirical findings that together have formed the foundation for development of the HEAL-TecH model, presented above. This theoretical framework has relied heavily on the relevant work of Everett M. Rogers and his diffusion of innovations theory, Bruce G. Link and Jo C. Phelan and their fundamental cause theory, and the work of Pierre Bourdieu and his forms of capital. Their integration into a larger theory informing the development of the HEAL-TecH model is described below.

Rogers' diffusion of innovations theory (first published in the 1960s and further developed in later decades) has been widely used and accepted as central to explaining the mechanisms that drive patterns in the spread (or diffusion) of innovations throughout society (Rogers *2003*). It is responsible for popularizing the traditional diffusion curve (or S-curve) and the systematic classification of adopter categories (as illustrated by Fig. 2).

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Fig. 2

Diffusion of innovations. (Adapted from Rogers (*2003*) showing the diffusion S-curve and adopter categories distributed along the mean and standard deviation of a normal distribution of the total population)

The fundamental cause theory (FCT), on the other hand, is a theoretical understanding of mechanisms of social stratification that unequally (re)distribute the resources that (re)produce health or, in other words, of the social distribution of health inequalities (Phelan and Link *2013*). Empirical tests of the theory have offered support to its assumptions, largely relying on investigations that illustrate the unequal effects on health of relevant innovations. The fundamental cause theory, and its highly "social"-ized (rather than individualized) perspective on the (re)production of inequalities in health is the result of many decades of developments in fields of epidemiology and sociology. These modern developments have contributed to increased attention on the structural mechanisms that determine individual and population health. In addition, Bourdieu's work has recognized that important sources of both economic and non-economic forms of capital (i.e., “symbolic” capital) are often misrecognized as legitimate forms of unequal power and social dominance (i.e., “symbolic” violence). Bourdieu’s work has provided a foundation by which to both largely contextualize and further develop the fundamental cause theory and the diffusion of innovations theory as they relate to explaining the relationship between technological innovations and the social mechanisms that drive inequalities. In this regard, it is in large part Bourdieu’s work that has provided a theoretical justification for revealing the subtle ways in which seemingly nonthreatening technological innovations in health may influence mechanisms, highlighted by the diffusion of innovations theory and the FCT, that (re)produce (dis)advantage and inequality across society.

Recently, some scholars have been addressing technological innovations and inequalities in health more systematically, in an attempt to further develop theories merging elements of the FCT with elements of the diffusion of innovations theory. Goldman and Lakdawalla (2005), for example, published an influential study contributing theoretical developments to the relationship between inequalities in health and technological innovation. Inspired by an attempt to more fully explain the persistence of education-based inequalities in health, and using a background in consumer theory, the economists theorized that improvements in the productivity, or effectiveness, of healthcare (i.e., innovative technologies) increases inequalities by favoring high SES individuals, who are also heavier users of health care services. However, they were also interested in investigating whether this is the case for all technologies or only for technologies that are associated with complex treatment regimens (technologies that simplify treatment would reduce inequalities). The authors present a number of case examples in support of their theory, ultimately concluding that technologies associated with complicated treatment regimens increase inequalities, while technologies that result in a simplification of treatment regimens reduce inequalities (Goldman and Lakdawalla 2005). This conclusion would seem to fit with, but is not linked in the study to, the diffusion of innovation’s findings regarding complexity in adoption rates – see Generalization 6-3 in Rogers (2003). Moreover, Glied and Lleras-Muney (2008), inspired by previous models to test the FCT, find a significant educational gradient in mortality for diseases where technological innovation is well developed. Their findings are based on the hypothesis that educational gradients in mortality increase when the rate of innovation in health technology increases (in this case measured by the number of active drug ingredients available to treat specific diseases). Although this study increases attention for FCT as a valuable theory for addressing technological innovation, the authors admit that their analysis does not allow for investigating specific mechanisms that link education with technological innovation. Although seemingly inspired by general understandings from both theories, neither of these publications make any attempt, however, to explicitly integrate the diffusion of innovations theory with FCT (in fact, neither of them even mention the diffusion of innovations theory and Goldman and Lakdawalla (2005) make no specific reference to FCT either). In contrast, Korda et al. (2011) address the diffusion of innovative health technologies and inequalities in health by combing principles from both the diffusion of innovations theory and an empirical test with familiar similarities to tests of the FCT. Grounded in perspectives based on the traditional diffusion curve and characteristics of adopter categories, and drawing parallels between “change agents” and clinicians, Korda et al. (2011) used coronary procedures in patients with ischemic heart disease to show that the diffusion process of this technology followed a socioeconomic gradient. In other words, high SES individuals showed significantly faster adoption rates for some of these technologies, increasing inequalities in associated health outcomes and leading them to conclude that the results were consistent with Hart’s (1971) inverse care law. The value of this study is in its ability to illustrate the import influence of rates of diffusion (of innovative technologies) on associated inequalities. However, it is Chang and Lauderdale (2009) who *explicitly* incorporate FCT and the diffusion of innovations theory in a study investigating inequalities in health. The strength of this study lies not only in its integration of these two theories but in their attempt to offer both an empirical test of their assumptions and the further development of theoretical perspectives. They use relevant theoretical developments of the diffusion of innovations theory and FCT to guide an empirical test of the FCT by measuring inequalities in health before and after the implementation of statins (standing in as an innovative health technology). Their study illustrates a reversal of inequalities in cholesterol levels from a relatively weak gradient favoring *low* SES individuals (i.e., favorable cholesterol levels) before the availability of statins, to a significant gradient favoring *high* SES individuals after significant diffusion of statins. Furthermore, they use their results and relevant theoretical models to further develop a theoretical understanding of innovative technologies as important influential resources affecting inequalities in health. They discuss multi-directionality in causal pathways between SES and technology (i.e., SES may affect access to technology but technology also affects the resources that are tied to a particular SES) and suggest that the strength of these effects are dependent on rates of diffusion and patterns of adoption (Chang and Lauderdale *2009*). The findings and conclusions of this study highlight the potential of systematically integrating perspectives grounded in both the diffusion of innovations theory and the FCT to "provide a detailed look at one piece of a complex web of events… [in] a larger process wherein disparities are maintained over the long run" (Chang and Lauderdale *2009*).

Nonetheless, it is somewhat surprising that the striking similarities between the FCT and the diffusion of innovations theory has not appeared to motivate a greater number of scholars and researchers. Neither have any of the original or later developers of the FCT nor scholars in relevant fields explicitly addressed the promising systematic integration of these two theories to explain broad social mechanisms related to innovations and inequalities in health (Weiss et al. *2018*). The similarities between the two theories are sometimes striking. In his description of the diffusion of innovations theory (limited, for unknown reasons, to individual behavior change and not innovations broadly), Mackenbach (*2012*) states, in reference to relevant research on the topic, that "as predicted by this theory, these behavior changes tend to follow a trajectory through populations in which those with a higher social position adopt new behavior first…[and] as a result, this dynamic phase is characterized by large and widening inequalities in health behaviors, which in turn lead to large and widening inequalities in mortality." In their early test of the FCT, Link et al. (*1998*) similarly state that the aim of their study is "to observe the impact of public health efforts to implement [cancer] screens widely by examining the percentage of the population adopting them through time." Although in effect a diffusion of innovations study analyzing inequalities in SES-based adoption patterns of cancer screens and the potential effect on cancer-related mortality, the diffusion of innovations is never referenced. Moreover, in their updated overview and analysis of the state of FCT, Phelan and Link (*2013*) conclude that "if we can understand what leads to the demise of mechanisms and especially how that decline is related to flexible resources, we may open avenues to speed such a demise and reduce health inequalities." "Mechanisms" in this context are health-improving innovations in medications and treatment and diagnostic methods. Therefore, it appears that what Phelan and Link are referring to is merely the rate of diffusion (in their words, "demise") of innovations in health. It would appear then that Phelan and Link are postulating that if we can understand what leads to an increase in adoption rates (i.e., diffusion), we can actually *reduce* inequalities. If this is accurate, it would appear that integrating the FCT with the diffusion of innovations theory (which, to a large extent, explains the underlying factors that drive adoption and diffusion) would have significant implications for both research and practice.

To further illustrate the intersection between FCT and the diffusion of innovations theory, one last example is particularly revealing. In a recent study by Clouston et al. (*2016*) (in which Phelan and Link are, in fact, both co-authors) in the highly respected journal *Demography*, the FCT is theoretically discussed in relation to a number of relevant theories and, subsequently, paired with an empirical analysis designed to test their hypotheses. These hypotheses are built around an illustrative model with a focus on how inequalities in health develop (and/or persist) over time following the advent of medical technologies (what they also refer to as “lifesaving efforts”). Their model, illustrating what they call the “historical stages” of disease development and mortality in society, is found in Fig. 3. However, in Fig. 3 a traditional diffusion of innovations curve has been included (additions marked with an *).

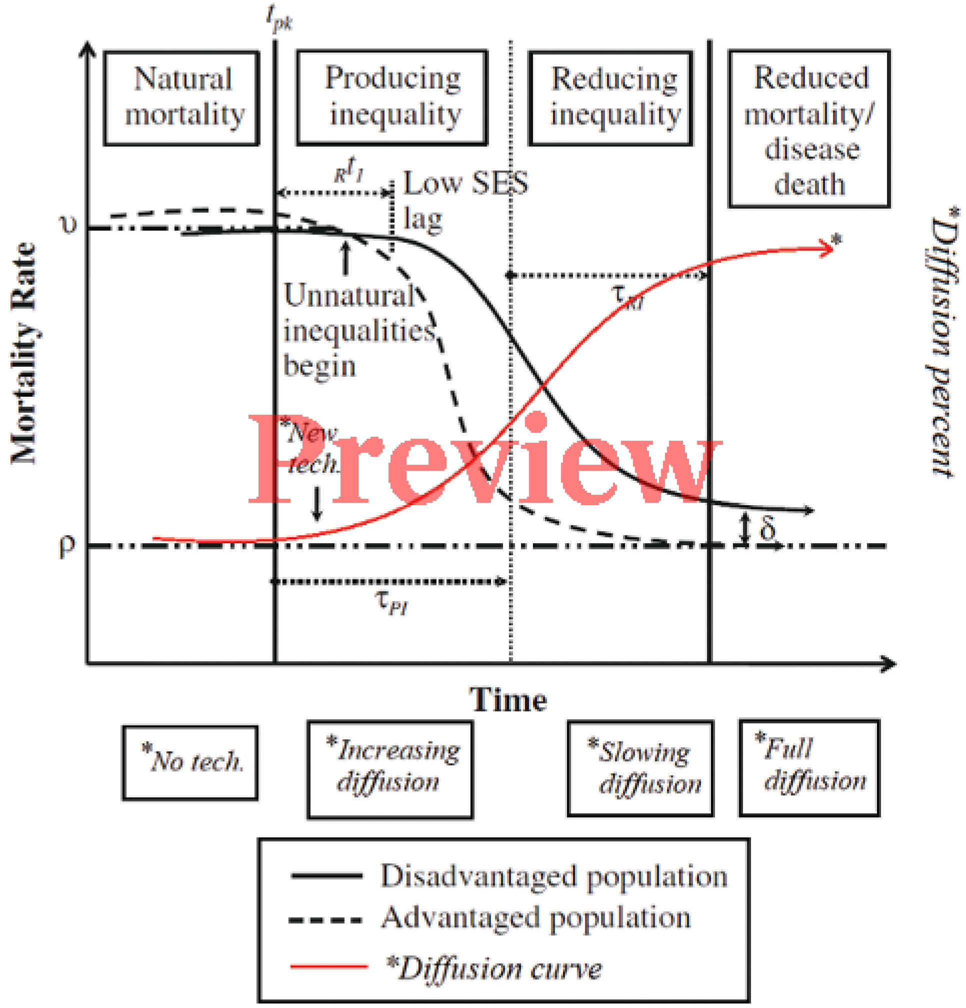

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Fig. 3

Ideal characterization of the history of the risk of mortality for a single hypothetical cause of death as it is increasingly but unequally controlled. (From Clouston et al. (*2016*) and adapted to include the diffusion of innovations curve) (new content marked with an *)

In this model, mortality rate decreases after the implementation of a medical innovation eventually resulting in very low or, in an ideal situation, zero mortality. However, throughout this process, the model illustrates that mortality is unequally distributed in a population. “Unnatural inequalities” in disease-specific mortality originate with the advent of a medical innovation, increasing over the short term but eventually decreasing over the long term (represented by the two mirrored inverse s-curves for “disadvantaged” and “advantaged” populations).

The stages represented by the Clouston et al. (*2016*) model reflect very closely the stages of the diffusion process outlined by Rogers (*2003*). In this case, inequalities are low or non-existent when no technological aid is available. Early stages of the diffusion process are marked by increasing inequalities, as innovators and early adopters begin to gain from the technology. As time progresses and the innovation nears full diffusion (i.e., as late adopters and laggards adopt), inequalities decrease. Simply replacing "mortality rate" on the y-axis in the original figure (which generally decreases with increased medical innovation) with "life expectancy" (which, in contrast, generally increases with increased medical innovation) would result in a curve reflecting the traditional diffusion curve first published by Rogers (2003) in the 1960s. The similarities between the FCT and the diffusion of innovations theory would seem to suggest, assuming that the two theories' central conclusions are considered valid and supported empirically, that the diffusion of innovations process may be a fundamental cause of the persistence of inequalities in health.

It seems apparent that the similarities between these theories deserve increased recognition and discussion by a broad range of scholars and researchers including the developers of the original theories. However, it is also apparent that both theories offer valuable insights independent of one another. The FCT offers a perspective firmly grounded in health and social stratification (both largely missing from the diffusion of innovations theory), and the diffusion of innovations theory offers perspectives firmly grounded in decades of empirical support from a variety of fields including sales, marketing, business, technology, and engineering (something largely missing from the FCT). Merely assuming that the FCT is solely a restatement of the diffusion of innovations theory, and therefore superfluous, would be both an oversimplification and an injustice to both theories. The value of these theories is not merely in their similarities but in their differences. Understanding these theories as complimentary theoretical frameworks and applying them in relation to one another (as a result of, rather than in spite of, their intimate similarities), it is possible for these theories to contribute, together, to more effective theoretical expansion, offering greater applicability and supporting broad explanatory power. Following this logic, it is possible for the integration of these theories to offer a more complete explanation of the persistence of inequalities in health. However, this logic would also suggest that other powerful interdisciplinary theoretical frameworks have the power to inform a grander theory of technological innovations and social inequalities in health.

The famous anthropologist turned sociologist, Pierre Bourdieu, is well known for his comprehensive work on the distribution and dynamics of power in society and the (re)production of social order. It is therefore unsurprising that his work may also contribute to a grander theory of technological innovation, social inequalities, and health.

Bourdieu is possibly best known for his work on the various forms of "capital" in society. Although economists have long, and continually, reminded society of the valuable role and importance of economic capital (which continues to dominate discussions), Bourdieu has influentially built a broader theory of capital, drawing attention to forms of capital that are no less important than economic capital but are non-economic in nature. Nonetheless, he does not overlook the importance of economic capital, particularly in relation to the accumulation of finances and wealth (i.e., money, property, and other financial assets) (Bourdieu 1986; Wacquant 1998; Fries 2009). However, two major forms of non-economic capital are central in Bourdieu's understanding of the distribution of power and resources in society. The first is cultural capital. Cultural capital represents knowledge, skills, and expertise often associated with formal academic education and informal intellectual or familial status. It is often officially embodied in institutionalized forms of reward or honor, such as academic credentials, employment qualifications, or cultural accolades/awards (Fries 2009; Wacquant 1998; Bourdieu 1986). The second is social capital. For Bourdieu, social capital is connection to durable networks of "more or less institutionalized relationships" (Bourdieu 1986) with varying levels of collective access to forms of valuable social and economic resources and power. Importantly, social capital tends to reproduce itself more effectively as its total increases (Bourdieu 1986; Wacquant 1998; Fries 2009). All these forms of capital empower and entitle its owners and inheritors to relative positions of social status within the dominant social hierarchy and each form can be converted into, or used to acquire, other forms. In this sense, they are at one and the same time distinct, and indistinct, socially constructed forms of capital.

While economic capital is often thought of in terms of material capital, Bourdieu's social and cultural capital are often non-materialistic and, instead, symbolic in nature. Cultural and social capital are transferred, acquired, and applied in ways that are much less apparent than economic capital and are therefore predisposed to represent forms of what Bourdieu refers to as "symbolic capital," or in other words, predisposed "to be unrecognized as capital and [instead] recognized as legitimate competence" (Bourdieu *1986*). This is the essence of symbolic capital for Bourdieu, the idea that some forms of capital are, as Veenstra (*2017*) explains, "rooted in relations of power and domination but widely perceived to be legitimate and meritorious." The powerful symbolic (i.e., regenerative and hidden) nature of these forms of capital is a central source of their significance and forms a principal focus of Bourdieu's entire body of influential theoretical and empirical work. Therefore, understanding how technological innovations may fit into this broader network of various forms of Bourdieusian capital offers an opportunity to discover relevant mechanisms that influence the (re)production of health and inequalities across society in ways other than purely materialistic and in ways that are often difficult to recognize.

However, Bourdieu's contributions do not end with capital. Bourdieu has also made significant contributions to understanding the relationship between individual behavior and social structure, the spaces and the frames through, and in which, his forms of capital can be acquired and applied. These findings are represented by his ideas of "habitus" and "field." Habitus, for Bourdieu, is a form of "social conditioning" and a "conditioning of the social." It represents the predispositions, beliefs, practices, and "tastes" of social groups, which both shape and are shaped by the position and composition of these groups along the social hierarchy (Wacquant *1998*; Grenfell *2014*). As Karl Maton has elegantly summarized in *Pierre Bourdieu: Key concepts* (Grenfell *2014*), habitus "captures how we carry with us our history, how we bring this present history into our present circumstance, and how we then make choices to act in certain ways and not others." "Field," on the other hand, can be thought of as a cultural or social context, or space, in which individuals and groups pursue valuable resources and struggle for power (e.g., academia or corporate business). Wacquant (*1998*) identifies the nature of Bourdieu's "field" as "a battlefield wherein the bases of identity and hierarchy are endlessly disputed over." In simpler terms, however, "field" could be thought of as the "outer" mechanisms (the space in which the individual inhabits), while "habitus" the "inner" mechanisms (the space which inhabits the individual), patterning group behavior and social reproduction. Habitus and field are not independent of, but instead intimately shape, one another. Much of Bourdieu's work to illustrate and explain habitus and field has contributed to further sociological reconciliation of debates over social structure versus individual agency, rejecting a dualistic approach and instead integrating these opposing perspectives into a consolidated theory of practice.

Together, Bourdieu's theoretical and empirical work have been hugely influential in "unmasking" the seemingly benign, yet misrecognized, nature of social forces and forms of valuable capital that powerfully shape the social space and (re)produce advantage and disadvantage between and within the social hierarchy (Wacquant *1998*). Such a comprehensive understanding of society seems a valuable, and arguably necessary, integration for a greater theory of technological innovations, health, and social inequality. Bourdieu's work provides a foundation by which to inform a more comprehensive understanding of the mechanisms under investigation in both the FCT and the diffusion of innovations theory (a more complete "theory of practice," if you will). However, it also contributes to revealing the subtle ways in which seemingly nonthreatening technologies may in fact have important implications for (re)producing (dis)advantage and inequality.

Wacquant (*1998*), for example, explains that, "contrary to a common (mis)reading of [Bourdieu's] work, his is not a utilitarian theory of social action in which individuals consciously strategize to accumulate wealth, status, or power." This would seem to diverge with FCT, which posits that valuable resources are "deployed" by individuals, insinuating conscious action at the level of the individual. However, rather than interpreted this as a challenge to the FCT, Bourdieu's perspectives can be used to refine the FCT's central assumptions. Veenstra (*2017*) has, for example, conceptualized Bourdieu's theories of symbolic capital as a way of adding necessary structure and substance to the FCT. This as a response to some of the often-cited limitations of the FCT and a general lack of the theory's syntactical and conceptual precision. Veenstra has, in fact, suggested that, of the dominant theories of social stratification, Bourdieu's theories are best suited to compliment and further develop FCT (Veenstra *2017*). He presents Link and Phelan's "money, knowledge, prestige, power and beneficial social connections" as representations of Bourdieu's forms of capital (economic, cultural, social, and symbolic). For Veenstra, "money" can be thought of as economic capital, "knowledge" as cultural capital, "beneficial social connections" as social capital, "power" as a product of all forms of Bourdieu's capital, and "prestige" as a misrecognition of the legitimation of any resource or, in other words, the representation of symbolic capital (Veenstra *2017*). Furthermore, Veenstra (*2017*) sees the interpretation of SES in FCT as represented by Bourdieu's positions in the field of power: socioeconomic status is the representation of an individual's position in and across fields.

Moreover, Bourdieu's theories offer significant contributions towards integration with the diffusion of innovations theory. Bourdieu, himself, has emphasized that "in a general manner, it is the people who are richest in economic capital, cultural capital and social capital who are the first to head for new positions" (Bourdieu *1996*). In other words, high SES individuals are the first to adopt new positions (of power) in society. The same is true for the adoption of technological innovations. However, possibly more interesting is the possibility that technological innovations, in effect, *create* these new positions (of power in society). Bourdieu has himself established that as innovative technologies disrupt established social structures, or what he refers to as "hysteresis," they create "field openings" where it is possible for individuals to occupy new positions of power in the disrupted social structures (Grenfell *2014*). As referenced above, these positions are generally recognized and occupied first by individuals with relatively high standing in existing fields of power, providing an opportunity for the concentration of power. As an example, the introduction of personal genome sequencing has disrupted the field of modern, institutionalized medicine, and created new openings for powerful advantage in personal health care and promotion by means of personalizing services and treatments. Occupying a position of high social status affords an individual with the opportunity to become aware of personal genome sequencing technologies early, by way of valuable social connections and a heightened awareness of developments in science and business. High economic purchasing power and social contact with institutions and organizations that provide these services again allows an individual with high SES to gain access to and exploit the potential of personal genome sequencing.

Although, as with the diffusion of innovations theory, it is assumed that groups in positions of lower SES will eventually follow into these openings (of power), Bourdieu and the diffusion of innovations theory have similarly highlighted that this process can take many decades (or never happen at all). In a time of exceptionally rapid technological innovation with larger numbers of total "field openings" and faster turnover (i.e., high rates of hysteresis), this could result in such rapid and consistent disruption of social structures that those who are not already in strategically beneficial positions of power fall further and further behind (Grenfell *2014*; Rogers *2003*). This theoretical construction of technology's position within a Bourdieusian perspective of hysteresis corresponds with and reaffirms central principles of the diffusion of innovations theory while also contributing to an expansion of the theory's relevancy for understanding the ways in which innovations influence inequalities and power in society.

Furthermore, Bourdieu's findings relating patterns of consumption with characteristics of the habitus lend further support for integration with the diffusion of innovation theory. Bourdieu has shown that consumption patterns are more similar within social groups than across them. These findings mirror the diffusion of innovation's conclusion that innovations are more often shared within, rather than between, social strata. Therefore, these findings would suggest that mechanisms embedded in the social distribution of social, cultural, and economic capital reinforce unequal patterns of adoption and diffusion. In *Forms of Capital*, Bourdieu (*1986*) declares that "to possess the machines, [one] only needs economic capital…." In other words, as long as a person has the economic means, one has access to technological artifacts. Although access, in reality, is more complex than this, it is often economic capital that is most obviously a mechanism by which individuals gain access to, or create material value from, technological innovations. Technological innovations are indisputably developed with profits as a priority and become a driver for state-sponsored consumer-based commercialization of economic value creation (MacKenzie and Wajcman *1999*). This acts on multiple levels including the state, corporate, and individual. At all levels, technological innovations create value for adopters; however, as Bourdieu states above, potential adopters are also often required to have a certain (usually relatively high) level of economic capital to gain access to these innovations.

However, it is important not to overestimate the apparent dominance of economic capital. As Rogers (*2003*) has highlighted, technological innovations are generally designed, developed, and delivered by high SES groups. Bourdieu's theory of habitus would then support the conclusion that the design, development, and delivery processes of these technologies are shaped by the embodied beliefs, views, ideas, skills, cultural expectations, and dispositions – i.e., "habitus" – of these high SES individuals. In fact, Bourdieu continues his earlier statement from *Forms of Capital* by stating that "…to appropriate [machines] and use them in accordance with their specific purpose (defined by the cultural capital, of scientific or technical type, incorporated in them), [one] must have access to embodied cultural capital, either in person or by proxy." Bourdieu's subtler forms of capital – cultural and social – are therefore intricately interrelated with economic capital in relation to technology-based inequalities in both access and use. Habitus and the preferences of individuals in a group (and their distinction from other groups) in relation to relative power over the entire lifespan of a technology (from idea creation to implementation and diffusion) would seem to be highly influential in determining relative advantage accrued by technological innovations. Bourdieu's theories suggest that technology, from this perspective, provides a form of symbolic capital that can also be a tool for asserting symbolic dominance. In other words, technology and symbolic violence are closely linked.

Symbolic violence is a form of domination that Bourdieu recognizes as a result of subtle forms of domination of relatively powerful groups over relatively powerless groups in society (Grenfell *2014*). It is a form of domination that is, as symbolic capital, mostly regenerative and hidden, exerting itself on its subjects with little or no conscious recognition. It is a form of domination often misrecognized as "natural social forces" but that reproduces the dominant social hierarchy and reinstates advantage where advantage previously exists, with little effort from dominant classes (Grenfell *2014*). As an example of the power of technological innovations in health as a mechanism for reproducing symbolic violence, one can consider the ways in which technologies are represented by the patients who use them. From an institutional agency perspective (for more on this, see, e.g., Weiss et al. (*2020*)), these technologies may represent an "ideal" patient who is engaged, informed, and resourceful and offers institutions with an apparently more worthwhile investment (Lutfey and

Freese 2005), reinforcing SES-based inequalities in access to health-improving technology and ultimately reinforcing existing advantage.

Resultant inequalities in mortality (often used as a measure of inequalities in health) may themselves be, according to Bourdieu (Grenfell 2014), the most brutal expression of symbolic violence. The effects of the mechanisms that reproduce this form of subtle domination indicate that it is not just binary access to technologies (i.e., "have or do not have") but also the *ways* in which these technologies are accessed, used, developed, implemented, and promoted that ultimately determines their status in society and influences how these resources differentially benefit social groups stratified by SES.

Implications for Society

Innovative health technologies are providing opportunities to both discover and treat medical problems before unknown. However, they are also providing opportunities to *create* health problems where they once did not exist. Although some of these discussions are not new, the implications of this development on contemporary understandings of the technology-based medicalization of society are significant (Gabe and Monaghan 2013). This is possibly in no better way exemplified than in the growing frequency and popularity of surveillance and monitoring technologies for health. These technologies (such as smart watches, phone-based apps and sensors, implanted biosensors, private genetics, GPS-based tracking devices, etc.), found increasingly both on the body and in the home, are used by individuals to actively and passively track, monitor, and share information pertaining to their health status. Advocated as improved means of personalizing care and services, preventing illness and promoting health (see Lupton (2016) and Weiss (2019)), these technologies have traditionally been, and in large part still are, available to individuals on the private market (i.e., "direct end-user" technologies, in the HEAL-TecH model). However, these technologies are increasingly spreading to encompass private insurance-sponsored and state-sponsored technologies as well as comprehensive institution-based technologies (classifiable as both "direct-use" and "indirect-use" gatekeeper technologies). In fact, State governments are currently responsible for actively promoting and purchasing these technologies in many forms (Weiss 2019).

Technological innovations in health are transferring public health and health-related concerns into every aspect of daily life (including active State-sponsored transfer of technology-based services into the home), expanding the "medical gaze" to a point in which individuals are increasingly and continually either monitoring themselves or being monitored by others (Lupton 2013, 2015, 2016). The result is a technology-enabled medicalization of society in which individuals are continually and constantly "at risk." In such an environment, even otherwise apparently healthy individuals are perpetually expected to see themselves as potentially sick or unhealthy (or, at the very least, not as healthy as they *could* be). Every individual is, therefore, constantly a single data point from finding what it is that makes them sick, unhealthy, or "at risk" (analogous with a state of "real-time continuous screening").

Although the consequences of increased medicalization are, of course, not categorically negative (e.g., increased medicalization can also lead to the social and medical acceptance of previously unaccepted "conditions"), decades-old scholarly discussions of the consequences have led to the recognition of its importance for experiences of power and control (Gabe and Monaghan 2013; Lupton 2013). As Lupton (2013) reveals in much of her research, "the techno-utopian ideals of the technologies…are frequently challenged in the lived experiences of the patients who use them." She, and others, highlight that the lived experience of individuals often leads to feelings of “domestication” and, at times, an increased transfer of control and power to the institutions that are responsible for developing, implementing, and managing the technologies that are contributing to this increased medicalization. The psychological burden of constant contact with “unhealthy” has been a concern for sociological and social epidemiological researchers for many years, particularly in relation to experiences of control and power (Lupton *2013*; Andreassen et al. *2018*). Henrik Vogt has elegantly summarized sentiments of some of these undesirable consequences, stating that “…there is something deeply unaesthetical about living your life as if you are constantly falling apart. It amounts to a profound lack of self-esteem. Like a frightened bird constantly surveilling the deadly ground even though it should know it can fly. There can be no healthy mind in a healthy body in the presence of a constant focus on disease, risk and suboptimality” (Vogt *2017*). The personal and social ethical implications of promoting such a culture are significant for a society that is increasing its dependence on technological innovations to create and shape both existing and future definitions and experiences of health and illness, particularly in regard to how these experiences differ across social strata.

The pro-innovation culture only adds to this dependence, artificially creating a need for new technologies. This artificial need only contributes to a further medicalization of society, as innovative technologies in health are not only increasingly accepted but actively promoted. The perpetually positive representation, and therefore promotion, of these technological innovations is a natural result of the integration of innovation into contemporary identities of both public and private institutions in a globalized economy (Sveiby et al. (*2012*) and Weiss (*2019*)). Both public and private attention are growing for the actualized potential of technological innovations in health as increasingly lucrative objects of commercialization, particularly in a globalized economy (Grenfell *2014*). Where private companies see large financial gains in owning personal data and selling products with lofty promises of increased lifespan and improved quality of life, State governments see opportunities for skilled job creation (although in some cases innovation could have the opposite effect), improving economic efficiencies, and concentrating global economic and technological power and superiority. These interests contribute to the increased techno-medicalization of society and a culture in which possibilities for misrecognizing increased corporate and State surveillance and monitoring as benign or positive improvements in public health efforts lead to very real transfers of power and control that have significant effects on the ways in which the advantages of these technological innovations are distributed among the population.

From an inequalities and health perspective, the increased techno-medicalization of society presents several concerns. First, as high SES individuals generally tend to be earlier and more reliable adopters of technologies and larger consumers of health, it is possible to theorize that this group is most affected by the adverse consequences of increased techno-medicalization. However, the same research emphasizes that these individuals also accumulate unequal advantage as a result of their existing positions in the social strata and their early adoption of these innovative technologies. Therefore, due to their positions of power in society, as the surveillance and monitoring of individual health increases, these individuals are likely to have the social, cultural, and economic capital necessary to both *reduce* the adverse consequences of these innovations while *increasing* their benefits. Furthermore, because of the increased importance of these technological innovations in accessing opportunities across society, generally late adopters of these technologies will be, to a larger degree than early (and enthusiastic) adopters, pressured (potentially apathetically) into adopting these innovations. This form of “coercive adoption” is more likely to increase the potential for these individuals to experience the negative effects of increased techno-medicalization, as their relationship with these technologies is likely to happen on grounds in which, relative to the innovators and early adopters, they feel limited influence over. In Weiss (*2019*), we refer to the consequences of these developments contributing to a “technological double burden” for low SES individuals. These individuals "generally obtain less overall benefits from these technologies yet are more dependent on the benefits they manage to obtain" and, moreover, "are less likely to be empowered by these technologies and more likely to be alienated from the potential benefits of these resources over time" (Weiss *2019*). This could be interpreted as a form of social domination that embodies the effects of Bourdieu's symbolic violence, where the will and desires of innovators and early adopters (i.e., generally high SES individuals) are increasingly being forced upon late adopters and laggards (i.e., generally low SES individuals).

What's more, the effects of relevant forms of symbolic violence, resulting in potentially misrecognizing the causes of technological innovation-based advantages in health and quality of life being concentrated with high SES individuals, are likely only to be strengthened in an environment where responsibility for public health is increasingly transferred to the individual. As technological innovations are pushed into an increasingly dominant position in efforts to improve public health (and contribute to economic efficiency and growth), public health will be increasingly defined by the restrictions of these technologies, shifting the burden of health to the users of these technologies. A potential consequence of this development is a rolling back of efforts to focus public health on "upstream" factors and an increasing focus on more proximal determinants of health.

Although many decades of research and practice have to a significant degree increased attention on the social determinants of health and inequalities, technological innovations (particularly trends in personalized technologies), with the support of increased attention on "personalized medicine," may once again move public health discourses in a direction focused on individual efforts to promote and control health (see, e.g., Gabe and Monaghan (*2013*), Lupton (*2015*), and Weiss (*2019*)). A shift in this direction is not without precedent, as a similar development in the field of epidemiology in the early years of the twentieth century proceeded scientific discoveries and developments in the field of germ theory. In any case, a development in this direction risks undermining many decades of groundbreaking multidisciplinary research to understand the macro-mechanisms, such as power and capital(s), that (re)produce health and inequalities and, instead, overrepresent individual agency – what one may refer to as the "de-socialization" of epidemiology and public health.

The "de-socialization" of epidemiology and public health would risk increasing the power of arguments in support of "individual blame" for poor public health. The dominant discourse would therefore emphasize personal responsibility and choice, and authorities could increasingly transfer responsibility for health to the individual, where the individual would be increasingly responsible for creating the circumstances that contribute to their health independent of sociopolitical contexts. This neo-liberalization of public health discourses on the back of technological innovations in health is already occurring.

Paradoxically, however, the predominantly positive representation of these technologies in dominant discourse relies often on an argument of individual empowerment. In other words, technological innovations in health are endorsed as instruments for increasing the freedom and autonomy of individuals. However, the premises on which empowerment are grounded often seem assumed a priori and are more likely to contribute to a sense of "false empowerment." This false empowerment, instead of decreasing dependence, simply transfers dependence from institutionalized services to technological aids and the companies that provide these tools. In this case, promoting a pro-innovation bias on the grounds of empowerment may actually result in the opposite effect for individuals who are most dependent on the effects of technological aids yet least influential in relevant production processes and political discourses. This misrecognition of the benefits of technological innovations in health garnered by early adopters and high SES individuals as universal goods for equal social welfare and general social progress may very well be the embodiment of what can be seen as a form of "innovation-inspired symbolic violence" and class-based dominance.

Implications for High-, Low-, and Middle-Income Countries

The work in this chapter aims to contribute to a more thoughtful and effective understanding of the persistence of social inequalities in health across modern welfare states more generally. It may, however, more specifically, offer insight into explaining, and possibly reducing, the unexpectedly high level of inequalities in health in the Nordic countries (i.e., the "Nordic paradox"). Although some results are mixed, relevant research suggests that wealthy countries, such as Norway and other Nordic countries, tend to support early and high rates of innovation adoption (Rogers *2003*; Comin and Hobijn *2004*; Packer et al. *2006*). Moreover, although the effectiveness of some of these innovations (and their effectiveness in relation to other forms of interventions) can be at times questioned, the overall effectiveness of these technological innovations tends to be positive (witnessed in large part by improvements in life expectancy and rates or severity of illnesses that can be treated or prevented using these technologies). However, although income inequalities are relatively low in Norway (and other Nordic countries), the importance of higher and longer forms of formal education is increasing. Inequalities associated with educational outcomes persist, creating an important and influential prerequisite for participation in much of the modern techno-society (Dahl et al. *2014*). Educational and other socio-cultural or symbolic (rather than purely economic), inequalities are important factors influencing variations in use of (particularly innovative) health technologies, also in the Nordic welfare States (as suggested by, e.g., Andreassen et al. (*2018*) and Weiss et al. (*2020*)). Therefore, so long as these inequalities persist, SES-based variations in technology use, and consequently the level of received benefits, are also likely to remain relatively high, reproducing inequalities. Furthermore, although rates of diffusion likely vary for many of these innovations and may even in some cases be high due in part to State efforts, rates of diffusion are not enough to explain or suppress the (re)production of inequalities associated with the development, adoption, and use of technological innovations in health. Even high diffusion rates are likely not enough to overcome the effects of high rates of effective innovation development and adoption, coupled with significant SES-based variations in how these innovations are used and exploited (as this thesis has demonstrated).

Traditionally, the modern welfare State would effectively mediate resultant inequalities. However, traditional welfare programs are poorly designed to meet the modern challenges associated with the growing influence of technological innovations on health and social inclusion and participation. The findings in this thesis illustrate that regardless of technology type, access and use patterns are shaped by SES (i.e., capital accumulation). Type 1 (direct end-user) technologies are influenced directly (e.g., by private purchasing power), while type 2 (direct-use gatekeeper) and 3 (indirect-use gatekeeper) technologies are often influenced indirectly. Furthermore, as Fjær et al. (*2017*) have demonstrated, when compared to low SES individuals, high SES individuals access and use specialist services more often, which is often a prerequisite to accessing many of these technological innovations. Moreover, regardless of access, high SES individuals tend to be more active users of these technologies (as demonstrated, e.g., in Weiss et al. (*2020*)). These modern technological resources, therefore, are allowing particularly high SES individuals to take control of their health in spite, and independent, of social welfare programs and policies designed to provide universal social benefits and moderate the growth of inequalities. In fact, Norway, for example, is actively promoting the use of technological innovations to transfer increased responsibility to the individual (Weiss *2019*). As individuals are increasingly "empowered" by State public health policies looking to promote the role of technological innovations in health, we could very well expect to see growing inequalities, as individuals who have access to more of society's resources are better positioned to use this advantage to obtain increased advantage. Therefore, using the HEAL-TecH model as a conceptual foundation, there is reason to speculate that generous welfare States such as Norway, who are actively promoting effective innovation, who have the economic and political means to stimulate the adoption of innovations at the national level, and who remain vulnerable to SES-based variations in the use of these technological innovations (regardless of the rate of diffusion), will continue to experience the (re)production of surprisingly high levels of inequalities. In other words, it is possible that developments in and around technological innovations in health are responsible for explaining much of the "Nordic Paradox" and may be influencing similar developments in social inequalities and health in other technologically advanced regions of the globe. These associations must be addressed specifically by future research. The HEAL-TecH model should provide a foundation for future research, where cross country comparisons can (and should) be used to investigate the relationship between the adoption of technological innovations in health at the national level, national welfare programs, and consequences for relevant social inequalities.

In contrast, a different situation may present itself in LMIC. These assumptions however are purely anecdotal, as research has not yet explicitly addressed LMIC contexts. However, the HEAL-TecH model may allow us to make some valuable predictions. LMIC's are often highlighted as models of technological inspiration, where devastating sickness and disease have been successfully managed, or general public health has been significantly improved, across large swaths of the population regardless of socioeconomic status. These examples, however, present a number of important contrasts with technologically advanced societies that, although do not undermine the value of these technological examples in LMIC, do undermine their value as reliable examples of successfully combatting inequalities in high-income countries.

First, the style and types of technologies being implemented in LMIC are often very different than those in more technologically advanced (i.e., high income) countries. Quite simply, the technologies often found in LMIC's are much less sophisticated. Although these technologies often provide innovative solutions in LMIC's, these technologies are generally old, outdated, or very simple renderings of technologies found in high-income countries.

Second, the contextually innovative technologies applied with often significantly effective success in LMIC are often used to treat very different types of illnesses or health-related issues than contextually innovative technologies in high-income countries. Although technologies in LMIC are increasingly being used to treat or prevent growing issues associated with chronic disease, successful technologically innovative interventions in LMIC are often used to treat communicable diseases. These are illnesses that much of the developed world has been able to successfully manage or eradicate for many decades, in large part a result of the widespread diffusion and implementation of the very technologies that many LMIC's have, for various reasons, had little access to (and which are, therefore, still contextually innovative in these countries). These, often quite simple (in regard to implementation, and not necessarily initial development), technologies have played a central role in, what Juval Harari has eloquently summarized as, the twentieth century's egalitarian public health project to heal the sick (Harari *2016*). This project, although largely successful in high-income countries, has not yet achieved the same diffusion, and therefore effect, in LMIC's. Therefore, when these effective forms of technological treatment reach these countries, often with the help of State or NGO sponsored programs, the effect of these technologies on public health across SES is significant and inspiring.

Modern innovative technologies in much of the technologically advanced (or high income) countries, in contrast, are being designed not to eradicate widespread illness and disease but, again as Juval Harari emphasizes, to "upgrade the healthy," or at least provide health enhancing services to those with the resources to access, understand, and use them. This is exemplified by the domination of the global health technologies market by companies in high-income countries producing technologies for high-income markets (Howitt et al. *2012*). In these high-income countries, the largely successful humanitarian effort to eradicate communicable diseases has been replaced with a largely capitalistic effort to create new markets for selling technological innovations in health to the relatively wealthy. For better or worse, it appears as if versions of these technologies are also being exported (or donated) to markets in developing countries (Howitt et al. *2012*). In any case, one must be very careful to use examples of success in using technological innovations in LMIC's to combat both devastating public health challenges and reduce social inequalities in health as an argument for assuming similar results for more advanced technologies in high-income countries. The HEAL-TecH model allows us to illuminate why.

Here the model allows us to further exemplify the importance of underscoring that simple, effective, state-sponsored technologies, often in part funded by, developed and administered by large national or multinational non-profit or humanitarian organizations in LMIC's would be expected to have very different effects on inequalities and health in those regions when compared to high-income, technologically advanced societies. The model can explain how a government-sponsored vaccination program or NGO-sponsored initiative to distribute insecticidal bed nets or water filters in a low-income country would promote the reduction of within-country inequalities in health-related outcomes, such as malaria incidence or water-borne bacterial infections. State sponsorship in a low-income country could provide high rates of diffusion and low rates of innovation. The simple yet effective design of an insecticidal bed net, for example, may provide a very effective intervention against malaria incidence which, according to the model, may promote relevant inequalities. However, this effect would likely be more than offset by the equalizing effect of limiting opportunity for variations in use patterns between users. Although somewhat of an oversimplification, a rather straightforward technology such as an insecticidal bed net, or vaccine for that matter, often allows for little more than a single means of health-related use: either it is used, in which case all or most of its benefits are attained, or it is not used, in which case none of its benefits are attained. Therefore, regardless of its effectiveness, a technology implemented in a LMIC setting characterized by low innovation, high diffusion rates, and low variation in use patterns would, according to the model, result in relatively low inequalities. Contrast this with the introduction of a technologically advanced, innovative digital glucose monitoring device, similar to our earlier example, to a free-market structure in a high-income country, where a lay user is expected to exploit this technology's functionality to manage a dynamic illness, and one would instead expect to see an increase in within-country inequalities. The above examples are important for contrasting contexts in LMIC's with those in high-income countries. It is, however, also important to highlight that LMIC's often struggle with many of the same issues of social inequality when implementing and adopting technological innovations in health as high-income countries (Howitt et al. *2012*). The HEAL-TecH model therefore provides a more nuanced and complete understanding of the complex effects of technological innovations on inequalities and health in both high-income and LMIC contexts.

Conclusions

Technological innovations have the potential to improve public health. However, they also do not benefit all social groups equally. Our findings have shown that high-SES groups tend to be more active users of health technologies and that merely focusing on the SES-based inequalities in access to technological innovations hides very real and potentially significant inequalities in SES-based patterns of use. Furthermore, SES-based gradients in the adoption of health technologies appear stronger for innovative, rather than old, technologies and for technologies with slow (or low) rates of diffusion. These innovations may therefore not contribute to *creating* inequalities but are important mediators of mechanisms that influence *the (re)production* of systematic inequalities. This is a result of the (increasing) importance of technological innovations for accessing and exploiting the benefits of valuable institutions, services, and forms of capital in society.

Technological innovations in health appear to have the power to both increase or decrease inequalities. The direction and magnitude of this relationship is shaped by a number of mechanisms at various levels of the social spectrum, which are dependent on important technological and sociopolitical contextual factors. In other words, technological innovations in health must be understood not just as powerful instruments for universal social "progress" but also as an equally powerful actor in the shaping of the social order. Current trajectories uncritically addressing the development and adoption of current and future technologies, assuming a generally pro-innovation and pro-technology attitude, may very well contribute to an aggregate improvement in public health but are likely to increase social inequality. Unintended consequences have potentially significant implications for society at large, including unequal burdens associated with the increased techno-medicalization of society, false empowerment discourses, and the "de-socialization" of modern public health efforts. Furthermore, contexts in LMIC's must be decoupled from contexts in technologically advanced high-income countries in order to fully understand the contextual effects of the adoption and diffusion of technological innovations in health on social inequalities. The mechanisms that allow technological innovations in health to influence social inequalities cannot be seen as simple, static, or regular but as complex, dynamic, and situational. The HEAL-TecH model provides an opportunity to provide clarity to this complexity and promote a more conscious engagement with the development and implementation of technological innovations in health in a society with growing social inequalities.

In the future, technological innovations are sure to be of increasing significance in the way society engages with both individual and public health, and social inequalities will likely be increasingly affected by the ways in which society engages with these technologies. As a result, a number of concerns present formidable challenges for the future of society. The ownership of big data by large multinational tech companies used for health purposes should be of major concern. Particularly as these datasets often provide poor representation of already disadvantaged social classes. The influence of technological innovations on labor markets and their indirect effects on (often blue-collar) workers' ability to access and use services, institutions, and other forms of capital that provide or promote health should also be of major concern. As should be very apparent social inequalities in access to technological innovations that can reduce or manage the increasing effects of climate change. These technologies will surely have significant effects on individual and public health and associated inequalities, particularly as vulnerable populations are already bearing the largest burden of a changing climate. However, the most concerning development of all may be the potential replacement of traditional social classes with what can only be understood as biological social classes. Technological innovations in health are increasingly providing a means for individuals with the economic and cultural capital to purchase or obtain biological advantage, by manipulating the genome or upgrading body parts. Be this the case, humanity would once again have an opportunity (as we, unfortunately, did in a time of much greater scientific ignorance) to divide society into the biologically superior elite and the biologically inferior slave or worker classes. This time, however, this social sorting will not be a result of scientific ignorance but of scientific *discovery*. It does not, however, have to end this way. The HEAL-TecH model, and the research that has resulted in its development, illustrates that the mechanisms that drive the development of technological innovation in a direction that has the potential to either increase or decrease associated inequalities is a product of human decisions. A conscious and informed social and political decision-making process has the potential to contribute to a direction in which technological innovations help to solve humanities greatest challenges, rather than promote them.

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