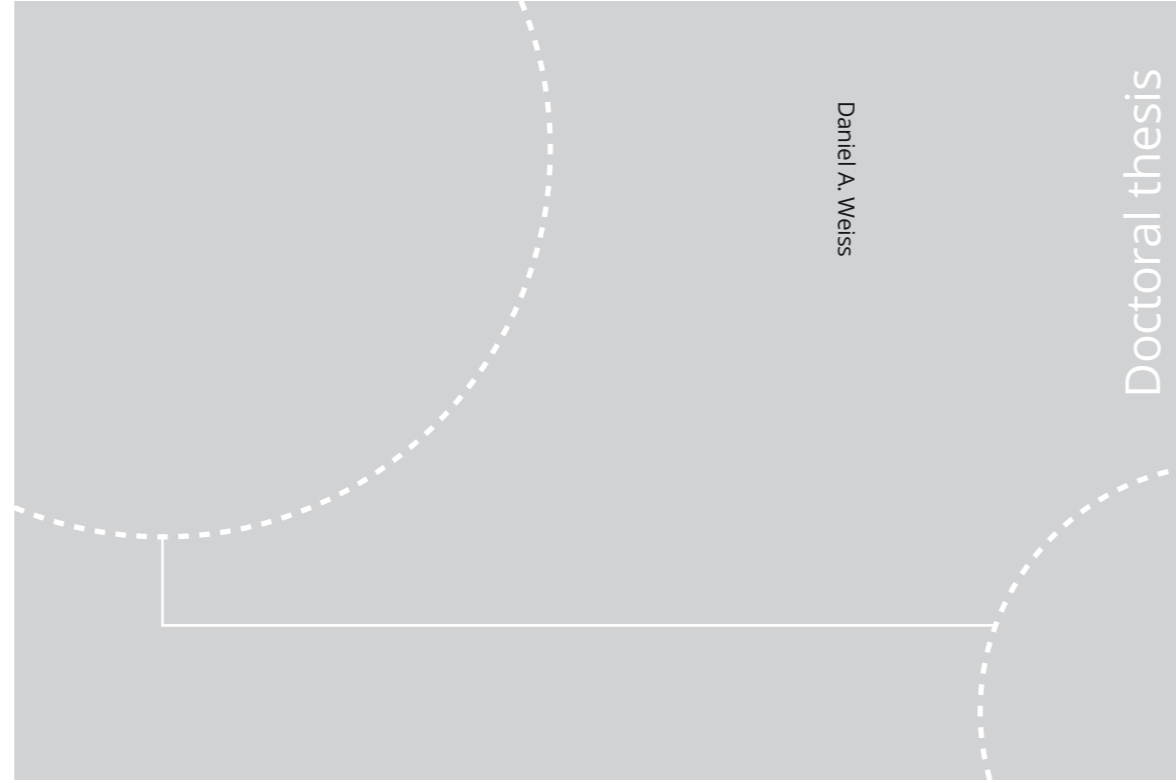


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Daniel A. Weiss

The Pro-Innovation Paradox:

Social inequalities and health in an age of technological transformation

 **NTNU**
Norwegian University of
Science and Technology

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Norwegian University of Science and Technology
Thesis for the Degree of
Philosophiae Doctor
Faculty of Medicine and Health Sciences
Department of Public Health and Nursing

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Thesis for the Degree of Philosophiae Doctor

Trondheim, September 2020

Norwegian University of Science and Technology
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Department of Public Health and Nursing



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TABLE OF CONTENTS

Table of Contents	1
Acknowledgments	5
Summary.....	9
1 Introduction	17
1.1 Technology and society.....	17
1.2 Technological innovation and the state of modern health and inequality	21
1.3 The Norwegian case	27
1.4 Aims and objectives: perspectives guiding the research.....	30
2 Theory & Background.....	33
2.1 Technology and the diffusion of innovations	33
2.1.1 Towards a definition of technology and innovation	33
2.1.2 The diffusion of innovations.....	37
2.2 Social inequalities in health and the theory of fundamental causes	47
2.2.1 An intellectual evolution.....	47
2.2.2 Identifying 'fundamental causes'	52
2.3 The development of a grander theory.....	57
2.3.1 Fundamental causality and innovation	57
2.3.2 Technology as 'symbolic' capital	61
3 Methods & Data.....	67
3.1 Data sources	67
3.1.1 Survey and register data	67
3.1.2 Political documents	67
3.2 Methodological perspectives	68
3.2.1 Measuring social inequalities (in health).....	68
3.2.2 Class as a contextual factor	72
3.2.3 The "toolbox perspective" or "methodological polytheism"	75
3.3 Ethics	84
4 Summary of articles.....	86
4.1 Paper I	86
4.2 Paper II	87
4.3 Paper III	88
4.4 Paper IV.....	89
5 Discussion.....	91

5.1	Summary of findings.....	91
5.2	HEAL-Tech: The presentation of a conceptual model.....	92
5.3	Implications and conclusions.....	99
6	Afterword.....	107
7	References.....	114
8	Paper I.....	119
9	Paper II.....	125
10	Paper III.....	145
11	Paper IV.....	163
12	Appendix.....	179
12.1	HUNT I questionnaire.....	179
12.2	HUNT II questionnaire.....	184
12.3	HUNT III questionnaire.....	189

This thesis is dedicated to two very important people in my life:

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The days I have spent in the office have seldom been poor. This is in many ways in thanks to the colleagues I have spent the last few years with. The days punctuated by interesting theoretical, methodological or empirical breakthroughs have often been stimulated by support from my colleagues. I have been lucky to work with incredibly resourceful, smart and supportive colleagues who I am very thankful have always been there to share good advice, good research, interesting thoughts and ideas, or just have a good chat over a cup of coffee. I particularly want to thank the two other PhD candidates that formed the central core of my project team. Emil Øversveen for his extensive understanding of sociological literature that has shaped the way I have approached my work more than I could have expected or hoped, and who I feel I have shared the professional side of this journey's growth experience the most with these past years. And Håvard Rydland for his understanding of quantitative methods, his contributions as a smart political scientist, and his shared experience of being a new father and a PhD candidate simultaneously. To both of you, I have very much enjoyed our conversations throughout these years, and I have become a better researcher because of you both. I will, however neither forget the others that I have had the pleasure of sharing a

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SUMMARY

INTRODUCTION TO THE PARADOX

Technology is power and control. It can give life and it can take life. It can strengthen existing social hierarchies, or it can rewrite them. Society, in many ways, is a product of our technological innovations. They are often seen as both a sign and a source of social progress. While we are continually reminded of their benefits, their consequences are becoming increasingly obvious. At the very same time, global socioeconomic inequalities are at historic levels. And on the rise. This includes inequalities in health and welfare, within countries and across continents. While our technological innovations are often defended as public health miracles, improving health and welfare throughout society, they are also a valuable resource like any other, unequally distributed across society. And it is this collection of resources that in large part determines health both at the individual and population level. Therefore, health provides a valuable means of understanding and analyzing social inequality. An interest in investigating whether or not our technological innovations are contributing to a reduction or an increase in these health-related inequalities therefore presents a possible paradox. A 'pro-innovation paradox' suggests the possibility that our blind faith in technological innovations as unquestionable tools of social salvation may very well be contributing to a culture completely unaware of the possibility that the unintended and undesirable consequences of these innovations is undermining the benefits, and aggregate social value, that we have come to expect from our technological innovations.

Using data from the Norwegian population as a case, the overall aim of this thesis, therefore, is to provide a greater understanding of how innovative technologies are (conceptually and empirically) linked to health and social inequality. Central objectives include reviewing the range, nature, and extent of relevant research exploring the influence of innovative health technologies on social inequalities and health, with specific focus on a deeper understanding of the variables used to measure this connection and the pathways leading to the (re)production of inequalities (Papers I & II). And moreover, to provide a broad framework supporting a deeper scientific understanding of the mechanisms and pathways explaining the complex social and political relationship between technological innovations, social inequality and health (Papers III & IV).

THEORY & BACKGROUND

Defining both technology and innovation have been crucial to achieving the aims of this thesis. Therefore, using various interdisciplinary definitions of technology and a broad understanding of public health, the following working definition is reflective of much of the work in this thesis:

Technological innovations in health are: 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.

A three-type classification of technologies (developed in Paper II), furthermore, illustrates a model of understanding technological innovations in health as they relate to mechanisms driving status-based inequalities in access and use (figure 1). Type 1 (*direct end-user*) technologies are directly accessed and used by end-users, type 2 (*direct-use gatekeeper*) are accessed by way of a gatekeeper but used by the end-user, and type 3 (*indirect-use gatekeeper*) are both accessed and used by someone other than the end-user.

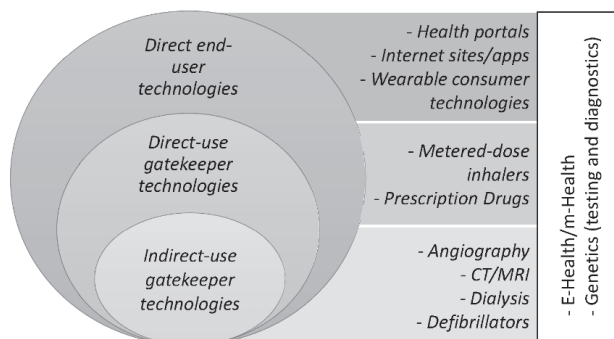


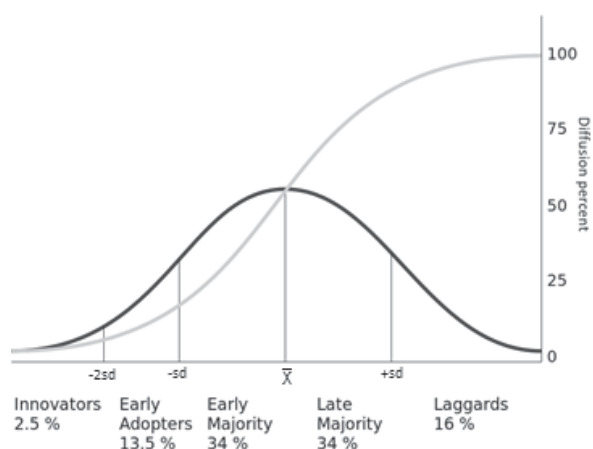
Figure 1: Classification of health technologies including a (non-exhaustive) list of example technologies (Weiss et al., 2018).

Understanding technological innovations in health in this way allows the academic literature to move beyond simply defining health technologies as medical technologies confined to society's health care institutions (as has often been tradition in these fields) and incorporating, instead, a broad conceptual understanding that captures the widespread effects of these innovations on society.

Theoretically, the work in this thesis has been largely inspired and informed by two major sociological and social epidemiological theories: the diffusion of innovations theory,

developed by Everett M. Rogers, and the fundamental cause theory, developed by Bruce G. Link and Jo C. Phelan. The diffusion of innovations theory is a theory that has been widely used, and accepted as central to explaining the ways in which innovations spread throughout society. It is responsible for popularizing the traditional diffusion S-curve and the classification of adopter categories (as illustrated by figure 2, below):

Figure 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. 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. These influential structural theories have been complimented by, integrated with and further developed using a number of other theoretical and empirical, scholarly contributions, including in large part Pierre Bourdieu's work on capital, habitus and field. Bourdieu 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 further develop the fundamental cause theory and the diffusion of innovations theory and

contributed to revealing the subtle ways in which seemingly nonthreatening technological innovations in health may influence mechanisms that (re)produce (dis)advantage and inequality across society.

METHODOLOGY

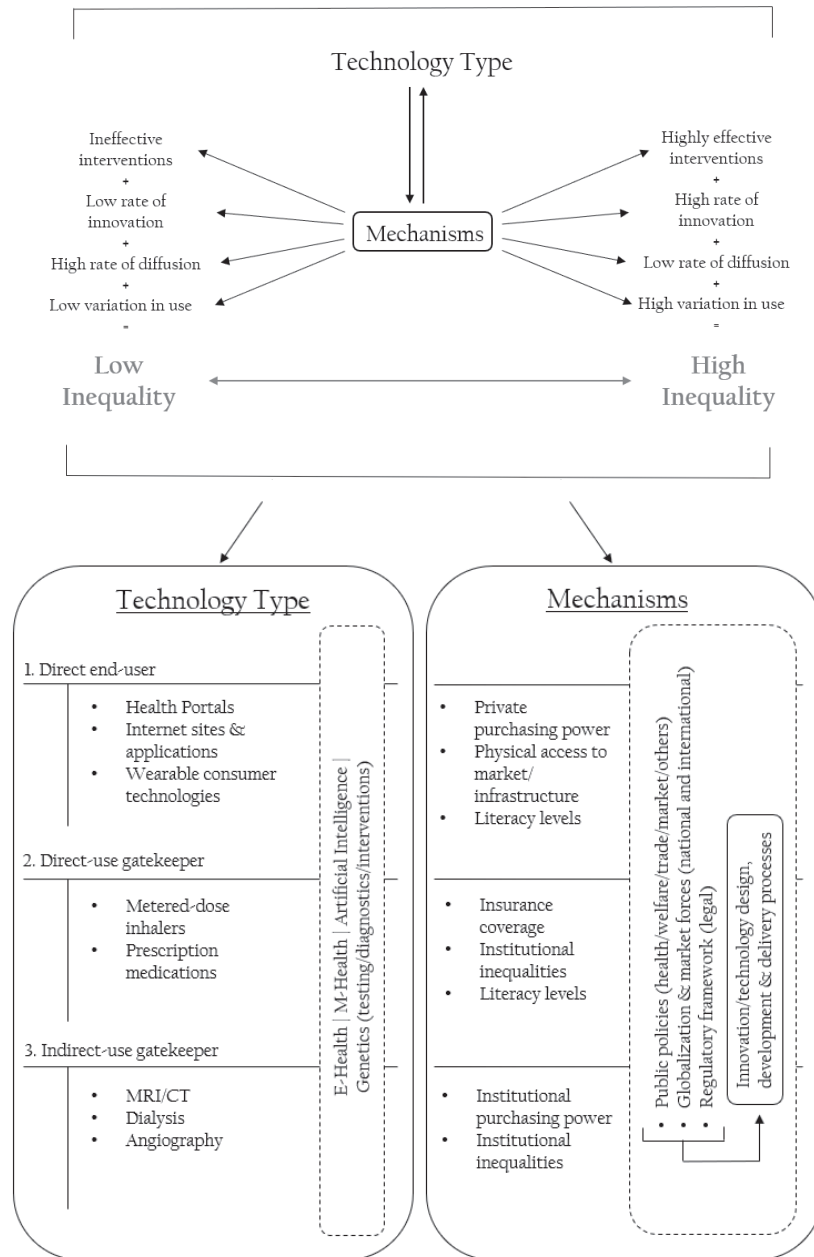
Data sources for the empirical work in this thesis have included diabetes data from the Norwegian Health Survey in Nord-Trøndelag (HUNT) and demographic data from the Norwegian population registry, as well as Norwegian State policy and planning documents.

Empirical methodology has relied on a 'methodological polytheistic' approach. This approach is grounded in a Bourdieusian approach to developing both a 'theory of practice' and a 'practice of theory', or in other words, a methodologically pragmatic and reflective approach necessary for building broad conceptual understanding. This thesis therefore relies on the use of scoping review methods (Paper II), quantitative statistical regression analyses (Paper III), and qualitative critical discourse analysis (Paper IV) to build a comprehensive understanding of the influence of innovative technologies on social inequalities and health.

RESULTS & CONCLUSIONS

Papers I and II have offered an overview of relevant literature and a classification of technological innovations central to perspectives interested in understanding their role in the reproduction of health and inequality. Paper III tests an empirical model for analyzing adoption and diffusion patterns of health technologies from a social inequalities perspective. Paper IV provides insight into dominant political discourse and its relevancy for the implications of technological innovations on public health and inequality. Furthermore, Papers II, III and IV provide evidence for a broad range of mechanisms, and potential pathways, illustrating how variations in access and use of innovative technologies (re)produce relevant inequalities. And, lastly, all papers provide relevant theoretical and philosophical discussions for further developing relevant scientific discovery. The findings from this work have provided a foundation for developing a broad conceptual model that can be used to further investigate, discuss, empirically test, and understand the ways in which technological innovations, health, and inequalities are interrelated (see figure 5, below).

Figure 5: 'HEAL-Tech' – a conceptual model for understanding how technological innovations influence inequalities in health.



The HEAL-Tech model presents a spectrum demonstrating the strength of observed inequalities as a product of the sum of several dominant characteristics of a technology's position in society. Moreover, the model illustrates that the type of technology importantly

determines the mechanisms most influential in (re)producing (or reducing) relevant inequalities.

Using the findings from the HEAL-Tech model as a conceptual foundation, there is reason to believe that generous welfare States such as Norway, who are actively promoting effective innovation, have the economic and political means to stimulate the adoption of innovations at the national level, and 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 relatively high levels of health-related inequalities. In other words, based on the findings from this thesis, it is possible that developments in and around technological innovations in health in Norway (and possibly other Nordic states) are responsible for explaining much of what has been deemed the 'Nordic Paradox' (i.e. surprisingly high inequalities in health in the Nordic welfare states).

Further findings suggest that technological innovations in health have the potential to improve public health but that these technological innovations do not benefit all social groups equally. These innovations 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, importantly, appear to have the power to either 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 socio-political 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. The implications for public health and inequalities of an increasingly technologized society include unequal burdens associated with the increased techno-medicalization of society, false empowerment discourses and the 'de-socialization' of modern public health efforts (where more responsibility is transferred to the individual). These consequences will only be strengthened by a pro-innovation culture, where national identities and economic superiority are increasingly associated with technological innovation. Misrecognizing the potential benefits of technological innovations in health for early adopters and high SES individuals as universal goods for equal social welfare and general social progress has significant ethical and practical implications for the ways in which social inequalities are (re)produced.

Moreover, the philosophical, theoretical and epidemiological findings in this thesis have the potential to make a number of concrete contributions to future developments in both research

and practice. First, they defend an understanding of technology as value-laden and therefore non-neutral. Second, they build on relevant theoretical and empirical findings, contributing a comprehensive overview of the mechanisms through which innovative technology either increases or decreases social inequalities (something which has not yet before been scientifically conceptualized or adequately investigated empirically). And lastly, they defend a more conscious and aware engagement with the development and adoption of technological innovation, its position in society, and its potential consequences. Engaging with technological innovation in this way is a prerequisite to challenging, and transforming, current assumptions and guaranteeing equal access to health as a universal basic human right.

1 INTRODUCTION

1.1 TECHNOLOGY AND SOCIETY

We find ourselves fully immersed in an age characterized by rapid technological innovation. This period of technological innovation is in large part a product of the modern industrial revolution, or what is often characterized as the fourth major revolution in human history (behind the cognitive revolution, the agricultural revolution, and the scientific revolution) (Harari, 2014). The advent of technological innovation has traditionally afforded the human species with superior efficiency or the ability to harness a novel skill, endowing both individuals and institutions in society with immense power (Cassell, 1993, United Nations, 2018, Feenberg, 2012, Chappell et al., 2006). This power is largely a product of increased control – over the constraints of the natural and physical world, but also over one another in a socialized culture^{1,2}. Technology has the ability to define, and rewrite, social hierarchies. To relinquish technological innovations is often to relinquish status and power (MacKenzie and Wajcman, 1999). Entire corporate sectors are dependent on technological innovation to create advantage and ensure survivability. At the global level, States have used technologies to win wars, dominate economies, and more recently, to rig democratic elections³. But technology also gives necessary structure, definition, and a central source of growth to our resource-based capitalist-consumer economies, which have lifted millions of people out of poverty and allowed us to feed many billions of people. Technological innovation has not just improved the lives of individuals but has also saved the lives of entire populations. Technology is therefore often referred to as a measure, and a source, of ‘social progress’ – an idea that was largely unknown before the advent of the scientific revolution, when human civilization began believing in the ability to merge science and technology to solve

¹ Some may even argue that technological innovation is what defines the human species (i.e. Homo-sapien the technologist). Therefore, the reason for which we as a species have been able to drastically, and to an extent unlike any other species, modify our surrounding environment. One could, of course, also argue that technological innovations rather have a “dehumanizing” effect, stripping us of agency and self-control.

² See Manuel Castells for more on discussions of the importance of technologies, particularly information and communication technologies, in creating culture and reproducing power, particularly by way of global (often digital) communication networks (in the new ‘network society’).

³ A good example is the nuclear bomb. Arguably, no single country has ever had as much global power as the United States when it possessed a monopoly on atomic weapons. Today, the mere passive possession of nuclear weapons can be enough to open up a seat at the global bargaining table. However, more recently, democratic elections in the same country that once possessed a global monopoly on atomic weapons, were significantly influenced by deliberate, but subversive, surveillance, monitoring and manipulation of voters via social media and internet-based technologies.

fundamental global problems previously assumed naturally unchallengeable⁴ (Harari, 2014, Feenberg, 2012, MacKenzie and Wajcman, 1999). Technology has, no doubt, had enormous impacts on society, many of which have been hugely beneficial. It is becoming increasingly clear, however, that the consequences of these technological innovations are equally disruptive.

In a landmark working paper, Oxford philosopher Nick Bostrom presents a compelling argument for the possibility of a not yet discovered technological innovation to trigger an end-of-civilization scenario (Bostrom, 2018). The concept, aptly named the *vulnerable world hypothesis*, uses what Bostrom calls the *urn metaphor*, to illustrate his fundamental argument. A symbolic urn contains an infinite number of balls each representing a single potential technological innovation. Each ball is a shade of black or white. The whiter the ball, the more insignificant are the potential consequences of the innovation for human civilization (the color white representing purity). The physical development of a technological innovation in society is equivalent to reaching into this urn and extracting a single ball. Once a ball has been extracted, it is virtually impossible to return it to the urn (i.e. we cannot undo our innovations). Most innovations are a shade of grey, containing significant but manageable consequences for human civilization, often outweighed by the innovation's benefits (think of an x-ray machine or an automobile). However, in theory, the urn also contains an unknown number of black balls. These black balls, Bostrom explains, have unmanageable and extremely significant consequences for human civilization – so much so that these consequences almost certainly result in global devastation of human civilization. So far, human civilization, the theory posits, has been lucky enough not to extract a black ball. However, particularly with the increasing pace of technological innovation, Bostrom argues, it is only a matter of time before we reach into the urn and unknowingly extract a black ball. Although Bostrom uses this argument as a foundation for the philosophical discussion of practical systemic solutions to safeguard against this black ball scenario, these solutions are understood as either practically unrealistic or various shades of dystopic future realities.

It would seem that the importance of Bostrom's thought experiment is to highlight, more so than the black ball experiment itself, the power of our technological innovations to reshape and radically influence society, creating, as the hypothesis suggests, a collective vulnerability of global proportions. Andrew Feenberg, building on previous work from Heidegger, has emphasized that technological innovations have the power to "transform what it is to be human" (Feenberg, 2012). More tangibly, technology and innovation are becoming so integrated into current social structures that they now have the power to determine how, and

⁴ This may also help explain why the terms *science* and *technology* are often used interchangeably.

to what extent, individuals and institutions can participate in society (see Castells (2007) work, for example, on technology's role in governing the modern 'network society'). These implications would suggest that as much as we may allow ourselves to have hope for humanity's technological innovations, we must also be skeptical of their consequences.

Although Bostrom's vulnerable world hypothesis provides an interesting philosophical discussion with realistic and potentially significant implications, it is possible, instead, to argue that the more likely, yet less alarmist, scenario is the accumulated effect of the consequences of many grey balls. The results of which may not spell complete devastation for human civilization but, rather, unintended and undesirable consequences great enough to cause significantly destructive cultural, social, economic, or political harm⁵.

Using Bostrom's theory as a reference point, current technological paradigms expect humanity to continually extract white ball technologies, or at least whiter in sum than previous technologies, resulting in a negative aggregate of unintended and undesired consequences. It may be true that many of the consequences of these technologies are often difficult to predict at the time of technological innovation but they are also often unpopular. Although it may be naïve to expect that technologies are always developed in society's best interest, it is also difficult to imagine support for a technological innovation whose social consequences clearly outweigh its social benefits. Our technological ideal expects these tools and innovations to solve problems and improve, or save, lives. Therefore, (whether or not it is true) our technologies are often defended, if not also designed, as means of improving daily living, increasing safety, or reducing pain and suffering. This is apparent in the quantity and breadth of technologies that have contributed to health and welfare. 'Modern' medicine is arguably the institutionalization and scientific pursuit of 'technological' medicine, exemplified by the central importance of machines, such as MRI and X-ray, and manufactured biotechnologies, such as medications and vaccines created in a lab. Lifestyle technologies, such as personal sensors and gadgets or smart-home technologies, are allowing individuals to monitor health status, stimulate healthy behavior or function more independently. Similarly, accident prevention technologies, such as seat belts in cars or increasingly advanced robotic systems, have reduced exposure to hazardous and sometimes deadly living and working conditions.

These technologies are often assumed to be inclusive social goods, improving or saving lives regardless of level of education or income, place of residence, social status, employment status, or ethnic background. However, although there is no doubt that technologies,

⁵ An obvious example is the gradual accumulation of unintended, unpredictable, and undesired consequences of climate change, which has been largely stimulated by technological innovation.

particularly health and welfare technologies, have improved quality of life, reduced suffering, and prevented unnecessary death and disease for many, basic principles in sociological theory allow us to nevertheless question this assumption. According to these principles, the following three mechanisms are central to the stratification of social structure: 1) social processes determining the relative value of specific resources; 2) the social norms and systemic controls on the distribution of these resources; and 3) “mobility mechanisms” that determine the position of individuals in relation to social hierarchies (Grusky, 2018). Technologies are arguably embedded in several of these mechanisms, significantly shaping the foundations of social stratification. First, the relative social value of technologies, in particular health technologies, is high. For now, it is enough to say that technologies can reinforce inequalities in the social distribution of power, money, knowledge, prestige and social networks, influencing access to other beneficial resources, acting as a symbolic form of currency, contributing to organized forms of hegemony (think surveillance and monitoring), and potentially strengthening existing forms of discrimination. Furthermore, powerful institutions in society are actively reinforcing, and in some cases strengthening, the position of technologies, including health and welfare technologies, and therefore structuring many of the mechanisms that contribute to the (un)equal distribution of these valuable resources in society. State authorities actively promote the development and implementation of health technologies, often in partnership with other powerful institutional actors such as research (including some of society’s most important educational institutions) and health care institutions, both public and private, and private industry. Although these institutions have various agendas, efforts often focus on the potential for technologies to increase economic growth or reduce spending, with improvements in public health and inequality forming ancillary objectives.

Therefore, in order to fully appreciate and seriously consider the larger social consequences of past, present and future innovations in technology, particularly technologies focused on improving general health and welfare, it is necessary to consider the effects of the presence of these technologies on society’s most vulnerable populations. Important questions must be answered around who these technologies are benefitting most and how, and in what ways technological innovations are (re)structuring the inner workings of present and future social organization with consequences for health, wellness and social prosperity. Doing so means recognizing that these innovations are far from neutral as they jockey for, and imbue, position and status within our financial markets, political systems and cultural traditions, where inequalities are not simply represented by adoption rates but also by subtle variations in how these technologies are used (Hofmann, 2002, Feenberg, 2012, Rogers, 2003, MacKenzie and Wajcman, 1999). In fact, debates about the neutrality of technology have a long history

(Feenberg, 2012). From these debates, one can argue that it is perfectly reasonable to expect relevant underlying social mechanisms to reproduce existing social inequalities, and possibly build new inequalities, into the lifecycle of an innovation – therefore supporting an argument for the “non-neutrality” of technological innovation. These influential effects may, furthermore, arise before a single dollar has been spent on the development of a technological innovation, and may persist (and possibly even grow) throughout the innovation’s lifecycle, with dramatic consequences for the distribution of resources essential for promoting and maintaining levels of health and well-being. This, then, introduces the importance of understanding whether the unintended and undesirable consequences of our technological innovations are challenging public health and increasing social inequalities, or whether we can have hope that they are, in fact, contributing to both a reduction in social inequalities and an increase in general population health.

1.2 TECHNOLOGICAL INNOVATION AND THE STATE OF MODERN HEALTH AND INEQUALITY

In his exhaustive updated analysis of *Capital in the twenty-first century*, Thomas Piketty establishes that global inequality in wealth in the early 2010’s is reaching levels not seen since the turn of the 19th century. Furthermore, he estimates that current structural mechanisms driving observable trends in the economies within and between State borders will only exacerbate trends in oligarchical wealth accumulation and, therefore, an increase in inequalities, both between and within countries (Piketty, 2014). The richest 10% of the population now own over 85% of global wealth, and the top 1% over half (Sharrocks et al., 2018). Attention for these inequalities is intensifying but, unfortunately, much of the discussion is still focused solely on economic inequality, giving relatively little attention to other important social inequalities such as those in education or health (Bartels, 2016, Piketty, 2014).

Inequalities in health, in fact, are also on the rise in many parts of the world. Individuals in low-income countries can expect to live, on average, approximately 20 years shorter than individuals in high-income countries (Institute for Health Metrics and Evaluation (IHME), 2018). Within countries, inequalities in health are no better, in some cases growing even in welfare states traditionally focused on strong social welfare programs and low social inequality. Cities in some of the most developed countries in the world, such as the U.K. and U.S.A., present disparities in life expectancy between neighborhoods *within their city limits* on par with those found between low and high-income countries (Marmot, 2015). In Europe, across 23 OECD countries, average life expectancy for men with high education is almost 8 years longer than for men with low education (Forster et al., 2018). Data from 20 European countries demonstrates that diabetes is reported over twice as often by low educated

individuals as for high educated individuals (McNamara et al., 2017). Referred to by many as a paradox, these inequalities prove to be no less persistent in countries with generous welfare systems, such as the Nordic states (Mackenbach, 2012).

Studying social inequality from the perspective of health provides a reference point for understanding the consequences of these inequalities. Although global trends in wealth inequalities should be alarming, they are only so because of the understanding of the importance of capital and wealth in society and the effect that absolute or relative levels of financial poverty can have on opportunities for individuals. Had capital and wealth demonstrated insignificant impact on life chances and well-being, financial inequalities would likely be of little interest for society. In fact, understanding the importance of income inequalities across countries, for example, can be extremely difficult without a certain level of context illustrating the effects of these inequalities on specific outcomes related to well-being⁶.

Health inequalities, however, illustrate much more explicitly the impact of relative and absolute social inequality. A 10-year difference in life expectancy or a 50% lower chance of developing an illness or experiencing complications from that illness are relatable and understandable measures of inequality. Furthermore, health outcomes are also often strongly correlated with an individual's position in relation to other socio-economic inequalities, such as those in relation to occupation, education, income or wealth (Mackenbach and Kunst, 1997, Marmot, 2015, Forster et al., 2018). In other words, health is in large part created by the accumulation of resources an individual or group possesses and is, therefore, a valuable means of understanding and analyzing social inequality as a product of the unequal distribution of these resources (Phelan and Link, 2013, Beckfield et al., 2013, Marmot, 2015).

The importance of technological innovations as a resource for combatting disease, reducing all-cause mortality and promoting public health has grown significantly in recent years, and therefore so too has their relevance for social inequalities (Woolf et al., 2007, Piot, 2012, Casper and Morrison, 2010). The years preceding the 19th century saw little in the way of technological innovations in the field of health and medicine. However, with the advent of dramatic increases in industrial efficiency and invention, the number of medical technologies also began to grow. Early medical technologies of this period were mostly a product of the field of chemistry. The 19th century saw advances in synthesizing new drugs to fight illness,

⁶ The same level of income inequality in two, neighboring countries can have a significantly different impact on outcomes related to individual quality of life and well-being. This is dependent on the significance of the influence of individual income on quality of life and the presence of social policies that may significantly contribute to buffering these inequalities.

the development of antiseptics and anesthetics to improve surgical procedures, and the development of bacteriology (with the help of the famous Louis Pasteur) led to developments in vaccines that have contributed to the complete extermination of once devastatingly deadly illnesses⁷. Powerful diagnostic tools such as radiology and the x-ray were developed in the later years of the 19th century. The turn of the 19th century and the early years of the 20th century gave way to significant advances in pharmaceuticals, and, building on the innovations of the previous century, a new round of surgical and diagnostic technologies as well as a wider range of effective vaccines. As innovations in these fields continued throughout the 20th century, entirely new fields of health technology entered the fray. The development and increased availability of computerized technologies in the latter half of the 20th century significantly and successfully increased the complexity of possible medical treatments and procedures. The availability of the internet revolutionized the potential for computerized technologies, creating an opportunity for “connected” information and communication technologies (ICT’s), which could communicate and share information remotely between individuals and institutions, to be used in the field of health. Increased digitization has supported these efforts. More recently, advances in bio, nano, and artificial intelligence technologies are contributing to a powerful and profound – some may say alarming – transformation in health and medical technologies. Powered by the information generated from the efforts to successfully sequence the human genome, some of these technologies are unlocking many of the keys to controlling the very processes of life and evolution – which goes without saying will prove to have an enormous impact on the way individuals and society treat and promote health.

Modern innovations in medical and health technologies have simultaneously seen a shift from predominantly traditional institutionalized “bedside” technologies, used and operated almost exclusively by health personnel, to personalized, and often commercialized, technologies that are accessed and used by individuals (Casper and Morrison, 2010). Take diabetes technologies for example, where 50 years ago it was not uncommon for glucose measurements and insulin injections to be administered solely by qualified health personnel at an institution. Today, however, it is both possible for private individuals to procure advanced measurement and injection technologies and employ them in any setting (work, home or even in the car) (Selam, 2010, Clarke and Foster, 2012). Some individuals are even hacking these devices to improve their function or increase customization. Personalized

⁷ Ironically, some of these deadly illnesses are making a modern comeback as skepticism for these once effective vaccines increase. Some may suggest that this skepticism is likely the result of a more pervasive general renaissance for the mistrust in technologies associated with an increasing, yet at times misplaced and misunderstood, awareness of the power of unintended consequences of technological innovations.

technologies, such as these and, in particular, advanced biotechnologies, are contributing to an intensification in the push for further developing the field of “personalized medicine”, where diagnostic and treatment tools and services are tailored to individuals based on biological predispositions and predicted response to illness and treatment. This push for a more personalized public health (or medicine) has promised to be more predictive, preventive and participatory – often defended as a more empowering public health, however these promises are questionable and often argued by stakeholders who stand to benefit financially (Juengst et al., 2012). In any case, developments in modern personalized, often portable, and increasingly sophisticated health technologies have led to radical transformations in methods for monitoring, surveying, and administering medicine and public health, resulting in technologies that are exporting health care and health promotion into virtually every sector of society and everyday life (Lupton, 2015, Lupton, 2016). Smart technologies in the home and workplace are continually monitoring and surveying individual’s health status, providing users, employers and health personnel (not to mention in some cases health insurers) with constant, updated health-related information and even providing, in some cases, alerts, advice or suggestions. Various styles of pumps and implants are allowing individuals to continuously undergo treatment procedures once available merely within the confines of health care institutions, regardless of geographical or situational context. And constant connectivity to internet-based communication technologies means that the doctor (or, maybe more sinister, the insurer, State or private company) is constantly one click away from sitting next to you in your pocket or on your wrist. Powered by the promise of social control and the corporate profits of multinational actors in the field of technology, such as Google, many of these transformations are again strengthened by the development of peripheral technologies that are increasingly being modified or reallocated as technology for public health and medicine, such as the use of big data to predict health behaviors and illness or target marketable innovations or services to specific groups of individuals. For some, the modern advances in medical technologies and innovations in health are bringing humanity closer to a genuine realization – some may say the ultimate goal of the human project – of elevating human power to god-like status whereby humans control the very biological processes that led to our evolutionary development and which have traditionally controlled the cycle of life and death (Harari, 2014). Whether or not this will come to pass is still up for debate⁸.

⁸ This may be the greatest paradox of all: that our technological innovations have the potential to imbue god-like powers but may also be the mechanism that drives our eventual extinction (or at the very least sets significant limitations on our current trajectory of exponential growth). Which of these scenarios occurs first – the achievement of god-like technological abilities or the technological destruction of the natural world and with it much of human civilization – may be the greatest question of our time.

One thing is certain, however, and that is the power and breadth of modern health technologies are likely to have enormous implications for developments in health and inequality (Rogers, 2003, Piot, 2012, Gabe and Monaghan, 2013, Casper and Morrison, 2010, Weiss et al., 2018, Hofmann, 2002, Hofmann, 2013, Veinot et al., 2018, Latulippe et al., 2017, Robinson et al., 2015, Andreassen et al., 2018, Harari, 2014). Nevertheless, the health and social sciences have traditionally been more concerned with investigating the lived experiences of individuals in relation to technologies in health and medicine rather than expressing an interest in the technologies themselves (Casper and Morrison, 2010). Only recently has there been an interest in investigating the greater implications of these technologies on society – such as the ways in which these technologies influence or challenge powerful social institutions or traditional understandings of the social structure (Casper and Morrison, 2010).

Such perspectives are becoming increasingly important as rapid technological development in the fields of public health and medicine are dramatically changing the way people access health. In some ways these technologies are contributing to a democratization of public health and care. ICT's, such as virtual exam rooms (telehealth) and internet-connected smart home technologies, are allowing individuals to remotely access important health information and to receive life-saving advanced care that would otherwise be unavailable. Simple and easy to use portable medical devices, such as smart watches and modern insulin pumps, allow individuals to administer self-care where large, expensive and often bureaucratically difficult to access institutions would otherwise be necessary. However, that these technologies are instead (or simultaneously) contributing to a less democratic and more polarized public health and care is equally plausible. As more traditional economies shift towards modern information-based economies and, therefore, a reliance on ICT grows, the use of these technologies as a gateway to knowledge, information and beneficial network acquisition may be increasingly stratifying society (Grusky, 2018, Castells, 2007). Furthermore, as markets for these technologies grow, commercial actors are developing technologies intended for individuals with the financial and cultural resources to access and use these resources. Smart home technologies are allowing individuals with the necessary financial resources to completely transfer the point of care, bringing entire portfolios of technologies into the home where it is possible to monitor health status and receive care. Internet-based applications and advanced personal sensor and implant technology is allowing individuals with the financial and cultural capital to gather detailed, continuous health information, which can then be used to influence health behaviors or demand extra levels of care and services. Expensive techniques used to map and analyze individual genetics is being used to personalize services for individuals that have access to the

financial resources and qualified personnel necessary to provide a level of care and prevention that is otherwise inaccessible to a large part of the traditionally “socialized” public health population. Rarely are these advanced, innovative forms of technology-based care covered by basic forms of public or private health insurance. As we will see in chapter 2, there are reasons to believe that it is only natural for these technologies to be accessed and used to a larger degree by individuals of high socioeconomic status (SES), eventually leading to the diffusion of these resources, and therefore also their benefits, to the rest of society. In some cases, this may be so. However, there is also reason to believe that the pace of technological innovation questions the underlying premises that this diffusion effect will ultimately lead to a more democratic distribution of these resources and reduce inequalities. Instead, these technologies may merely become the new normal, replaced by ever-more advanced innovative forms of technology-based care and services available only to a high SES social minority.

These trends towards more personalized health technologies, more personalized care, and increased commercialization of the resources used to deliver health care and promote public health would also seem to suggest, and promote, a more individualized public health and medicine. Society may increasingly associate human health with individual behaviors, personal decisions and individual resources rather than socio-political, cultural and financial mechanisms that structure the social environment and create opportunities for health, but which individuals (particularly those of low SES) often have less power to influence. We would expect the dominant political and social discourses to reflect this shift. This could very likely result in a general steepening of SES-based inequalities (i.e. the *social gradient*, more on this in chp. 2.2), due in large part to higher social standing and a greater collection of socially valuable resources determining access to beneficial effects provided by innovative health technologies.

However, there are no predetermined outcomes. As discussed above, evidence suggests that technologies have traditionally improved overall public health and continue to do so. That is, even the most vulnerable in society often benefit from technological innovation (although it should be noted that some evidence also suggests that society’s preoccupation with technological interventions saves much fewer lives than would adjusting other, more fundamental, social policies – see Woolf et al. (2007). Much of the same evidence, however, also suggests that these improvements are increasingly coming at the cost of growing inequalities.

A comprehensive understanding of how this is so, and why, is far from adequate. Further understanding of the mechanisms that drive such trends, and the circumstances that either

support or oppose these conclusions, are necessary to more fully explain the presence and persistence of modern social inequality. Moreover, a better understanding of the social consequences of technological innovations, including those in the field of public health and medicine, is necessary to promote a more conscious engagement with the processes of development, adoption and implementation of these technological innovations across society. Only then is it possible to secure the most effective integration of these innovative resources into current and future social structures and institutions. Consequently, it would be possible to ensure a future where the unintended, undesired consequences of technological innovations in health are minimized and, instead, contribute to health as a human right rather than reinforcing existing inequalities. As Freese and Lutfey (2011) have highlighted, “social science has an important role to play in our understanding of how the ultimate health benefits of public expenditures on science are distributed”. How this understanding relates to social inequalities and health in an age of technological transformation is no exception. Rather, as technologies become an increasingly important form of socio-cultural capital, investigating these relationships becomes paramount for the future of science and policy.

1.3 THE NORWEGIAN CASE

Current social inequalities in health present a challenge in Norway, exhibiting rates as high or higher than many other European nations (Huijts and Eikemo, 2009, Mackenbach et al., 2016, Mackenbach, 2012). In some cases, data suggests that Norwegian health inequalities are increasing (Mackenbach et al., 2016). In Norway, as is true for many nations, education-based gradients in health, for example, are both systematic and persistent. Research suggests that Norway experiences almost three times as many lost years of life in groups with low education compared to high education groups, and low educated individuals are over twice as likely to report the presence of long-term limiting disease as those with high education (Dahl et al., 2014).

Paradoxically, one would expect these inequalities to be lower in Norway for a number of reasons. Generous welfare regimes – of which Norway and other Nordic countries represent – are known to have strong mediating effects on mechanisms that traditionally increase social inequality and, therefore, these countries often present relatively low levels of social inequality (Beckfield et al., 2015, Mackenbach, 2012). These comparatively low levels of inequality are generally a product of welfare regimes that prioritize a combination of redistributive and compressionary policies with generous State financed provisions and a collection of influential mediating policies (Mackenbach, 2012, Beckfield et al., 2015). However, the surprising persistence of social inequalities in health in Norway and other Nordic countries, where generous welfare regimes often moderate the size and scope of

other social inequalities, such as in income, has led to the declaration of a, so-called, 'Nordic paradox' (Mackenbach, 2012, Popham et al., 2013).

The stubbornness of this paradox despite an aggressive public health strategy focused on reducing inequalities in health makes Norway an interesting subject of analysis. From a social inequality in health context, Norway can be considered a poorly understood irregularity, or, in other words, a potentially useful 'deviant case'. Norway's political strategy focusing on inequalities in health has, in fact, been referred to as the most ambitious of any western European welfare state (Whitehead and Popay, 2010). Although inequalities in health have been documented in Norway for a number of decades, a specific strategy focused on reducing these inequalities was only first politically systematized in 2006⁹. The introduction of a number of reports and white papers in the ensuing decade have followed-up on, and evaluated, these efforts (Dahl et al., 2014). The Norwegian strategy has focused on systematically addressing social inequalities in health with a "long-term" perspective focused on what has been deemed the *social gradient* (see chp. 2.2), promoting "universal solutions" (Dahl et al., 2014). In addition, a national public health coordination reform, which went into effect in 2012, resulted in an ambitious public health law with the explicit intent to "contribute to a social development that promotes public health, including reducing social health inequalities" (Helse- og omsorgsdepartementet, 2012). Furthermore, these broad policy objectives are supported by a Norwegian health care service that is heavily socialized. Health care is in large part funded by the State, i.e. inpatient care is free, where nearly every citizen has been assigned a regular general practitioner, services are in large part decentralized (in order to service the large number of citizens living in Norway's districts), and out of pocket payments for treatment and services are considered low (Ringard et al., 2014, Vikum et al., 2013).

Norway's single-payer system of health care is contrasted by other dominant forms of national health care system organization, such as those found in influential States such as the United States, Germany, and France. While the Norwegian model, similar to the U.K. model, is predominantly a public, tax-payer funded delivery system of health care, using predominantly public institutions, countries such as Germany and France offer universal systems of care but deliver coverage and services through a complex patchwork of various public and private insurance schemes and institutional arrangements (Busse and Riesberg, 2014, Chevreur et al., 2015, Cylus et al., 2015). The United States, on the other hand, lacks

⁹ Some say this is quite late in comparison to other nations however this could very well be a result of the socially democratic State system that has traditionally been successful at keeping inequalities relatively low and it is therefore only in more recent years that these inequalities have become an issue of concern.

both a universal system of coverage and relies heavily on private insurers and private institutions to deliver care and services to a large share of its citizenry (although some sectors of its health care system are significantly 'public', such as Medicaid, Medicare and VA services, and Obama-era reforms have increased coverage to millions of previously uninsured individuals) (Rice et al., 2013). Where systems rely more strongly on various degrees of fee-for-service and private insurance coverage (rather than free-at-the-point-of-service and universal public funded coverage), barriers often limit initial access and continued use of various forms of service and care, including those dependent on specialized forms of treatment and technological aids. Furthermore, these various health care systems are simultaneously a product of, and exist within, various forms of evolving welfare state organization, which again influence availability and use of health-related social services, coverage and programs. Importantly, States such as the U.K. and Norway, for example, support and encourage very different forms of welfare-state politics in spite of similar system organization. These differences encourage important variations in the delivery and, more importantly, (re)distribution of resources and services that create, promote and treat population health. The U.K. has tended to favor 'Anglo-Saxon' or 'liberal' welfare state policies¹⁰ that minimize decommodification effects and tend to increase inequalities in the access and use of health-related provisions, while Norway tends to favor 'social democratic' welfare state policies¹¹ that favor strong redistributive effects and generous social welfare programs designed to enhance overall public health and promote social equality (Germany and France would fall somewhere in between, considered 'conservative' or 'Bismarckian' regimes¹²)¹³ (Bambra, 2011). These organizational structures have important implications for the degrees in which resources for health – including technologies – are socially distributed across the various social groups that constitute a population. As a part of Norway's single-payer health-care system and generous welfare state programs, health technologies have, interestingly, been actively prioritized by the Norwegian government for at least as long as inequalities in health have been on the political agenda. Already in 1990, the Norwegian government established the creation of the Norwegian Competence center for information technologies in the health and social sector (KITH). Their mandate has been to develop standards and promote increased coordination and implementation of ICT between service providers in the health and care sectors. The result of these growing efforts and the eventual materialization of increased political interest for the development and integration of health

¹⁰ The United States would also fall into this category.

¹¹ As is common in the Scandinavian countries.

¹² 'Conservative' regimes are marked by limited redistributive effects but also a limited role of traditional market forces.

¹³ Nations such as Spain, Italy and Greece make up a fourth category: the 'southern' regime, which tends to be relatively fragmented, where some welfare policies are comparatively generous whereas others rely heavily on family and civic sector organizations.

technologies into the public health and care sector, led to the creation of the Directorate for e-Health in 2016.

As a consequence of the above conditions, the Norwegian case presents interesting opportunities for investigating the aims and objectives in this thesis. Case studies have many strengths, some of which include their ability to address complex issues and produce novel hypotheses, while also closely examining the validity of these hypotheses (George et al., 2005). The topics addressed in this thesis are of global proportions, incorporating concepts that include globally exploited resources of high value (i.e. technologies) and the internationally relevant conditions that both control the distribution of these resources and stimulate mechanisms that (re)produce social stratification (i.e. political, cultural, social, financial). These conditions are in the same moment unique to the Norwegian context and both affected and effected by international contexts. Therefore, the Norwegian context offers insight into conditions that are currently unique to Norway while also attempting to highlight the influence of internationally relevant social and political mechanisms. In this sense, the Norwegian 'case' can be seen as both a national case study and an international investigation.

The value in understanding this thesis as a case study allows for: 1) the appreciation of rich insight, generated from a multimethodological and interdisciplinary perspective; and 2) simultaneously acknowledging the scientific benefits of incorporating this work into broader geographical perspectives – or, in other words, applying these insights to a number of additional 'cases' intended to explain the ways in which relevant mechanisms operate differently under diverse political, geographical, cultural, or financial conditions (George et al., 2005). Therefore, the research in this analysis is intended as a foundation for both theoretical and methodological explorations into topics related to technological innovations, health and social inequalities.

1.4 AIMS AND OBJECTIVES: PERSPECTIVES GUIDING THE RESEARCH

The research in this thesis not only draws inspiration from overlapping and complementary fields of study but also includes an interdisciplinary perspective informing theoretical and empirical models. The interdisciplinarity of the research in this thesis is represented by, to varying degrees, the fields of clinical medicine, political science, public health, epidemiology, psychology, economics, sociology, and subfields of technologies, such as health informatics and media studies. More specifically, theoretical developments throughout are heavily influenced by research from the fields of sociology (see, among others, Bourdieu, Rogers, Lupton, Beckfield, Freese and Lutfey, Gabe), social epidemiology (see, among others, Mackenbach, Link and Phelan, Marmot) and, to a lesser degree, medical ethics (see

Hofmann) and economics (see, for example, Goldman and Lakdawalla). This is, additionally, supported by research from the fields of technology and engineering (see Cotterman and Kumar) and innovation (Sveiby, for example). Furthermore, methods of analysis are influenced, in particular, by statistical sociological and social epidemiological methods (see, for example, Freese, Chang and Lauderdale, Glied and Lleras-Muney, and Korda) as well as linguistic methods (see Wodak and Meyer, and van Dijk). Although, starting in Paper I, this thesis attempts to position itself within the fields of social epidemiology and medical sociology, it does not attempt to explicitly define itself within a particular field of the social sciences. Instead, its purpose is to contribute to the health and social sciences more broadly – as a unified and complexly interconnected single field of inquiry. In this sense, it can be assumed that the scientific approach in this thesis is one that finds value in disrespecting traditional constructs of scientific separation and autonomy within subfields of the health and social sciences. Only in this space of scientific freedom is one truly able to construct comprehensive and socially valid models of social inquiry and explanation.

The overall aim of this thesis is to provide a greater understanding of how innovative technologies are (conceptually and empirically) linked to health and social inequality. A multidisciplinary and multimethodological approach is therefore used to address the following central objectives:

- 1) To review the range, nature, and extent of relevant research exploring the influence of innovative health technologies on social inequalities and health, with specific focus on a deeper understanding of the variables used to measure this connection and the pathways leading to the (re)production of inequalities (Papers I & II).
- 2) To provide a broad framework supporting a deeper scientific understanding of the mechanisms and pathways explaining the complex social and political relationship between technological innovations, social inequality and health (Papers III & IV).

In order to achieve these aims the work in this thesis will, using broad scientific inquiry and the nation of Norway as a relevant exploratory case study:

- 1) Build on existing sociological and epidemiological understandings of the determinants of health and inequality, with a focus on understanding the influence of technological innovations in health (Papers I & II).
- 2) Empirically test hypotheses investigating the presence of mechanisms linking innovative technologies in health on health and inequality by developing and implementing quantitative methodological models (Paper III) and qualitative forms of analysis (Paper IV).

- 3) Contribute to the generation of new perspectives, in an attempt to better understand, explain and model the mechanisms and pathways that link technological innovations in health with the social (re)production of health and inequality (Papers II, III & IV).

2 THEORY & BACKGROUND

2.1 TECHNOLOGY AND THE DIFFUSION OF INNOVATIONS

2.1.1 Towards a definition of technology and innovation

It is *innovative* technology and not simply the broad social understanding of technology that grounds the aims and interests of the work in this thesis. The questions grounding the theoretical and empirical models of explanation in this thesis are concerned not just with how (in this case, health) technology influences social inequalities but what happens to inequalities in society throughout the process of developing and adopting *new* (health) technologies. For this, we rely in large part on the comprehensive work of Everett M. Rogers' widely used and supported *Diffusion of Innovations* theory, complimented in part by the work of a number of other scholars.

Rogers' *Diffusion of Innovations* is a theory of the mechanisms that control the diffusion of all innovations, however Rogers himself highlights that the innovations often discussed within the context of his theory are technological (Rogers, 2003). In the *Diffusion of Innovations*, technology is defined as:

“a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome” (Rogers, 2003).

Furthermore, technologies are characterized as having both a hardware component (“a material or physical object”) and a software component (“the knowledge base for the tool”) (Rogers, 2003). This distinction is important and highlights that a technology cannot be purely symbolic or cultural but must include a physical tool. Under this definition, knowledge, for example, is not itself enough to be defined as a technology. This definition would seem to correspond well with the understanding of *technology* by many other scholars in various fields (Wahab et al., 2012). However, this does not presuppose that technology can exist *without* knowledge. It is, in fact, not uncommon for technology to be equated to, and thereof defined as, applied science (MacKenzie and Wajcman, 1999). In this sense, technology is only technology in so far as it can be traced to the origins of scientific discovery and development – in other words the creation of knowledge. But this definition, in turn, lacks any regard for the materialization of physical elements to the application of this knowledge. As Bozeman (2000) proposes, it is, in fact, impossible to separate the tools of technology from knowledge, as a physical tool is, by definition, useless without the knowledge for its use and, therefore, knowledge naturally diffuses alongside the diffusion of a tool or technology. In this sense, tool (hardware) and knowledge (software) are bound and only in this inseparable relationship can technology exist. Naturally, then, one may assume that a higher level of

knowledge often promotes a generally higher level of exploitation and application (i.e. return on investment, or value, however not necessarily in the monetary sense) of a specific tool. In any case, due to its importance and position in society and science, the definition of technology unsurprisingly has a long history, steeped in cultural, social, political, financial, and historical context (Sveiby et al., 2012). A full review of this history is outside of the scope of this thesis, however, for intents and purposes of the work in this thesis (which differentiates itself from a narrow, clinical or technical definition – for more see Sveiby et al. (2012)), the definition of technology proposed by Rogers (2003) above, will suffice as a grounding position for further theoretical and empirical development.

The work in this thesis, however, is interested specifically in health technologies, which would seem to suggest that a general definition of technology is insufficient. As Timmermans and Berg (2003) have highlighted, The Office of Technological Assessment defines medical technologies as “the drugs, devices, and medical and surgical procedures used in medical care, and the organizational and supportive systems within which such care is provided.” This would seem to suggest that medical technologies are purely found within the institutions that provide care and services. Furthermore, somewhat in conflict with Rogers’ definition of technology, this definition seems quite ambiguous to whether or not these technologies are required to include a physical or material (i.e. hardware) component, with vague reference to “organizational and supportive systems” as (medical) technology. This definition would seem to also distance itself from, or completely ignore, technologies important for health that can, and are increasingly, accessed and used outside traditional health care and services institutions. This definition does not seem to include, for example, wearable consumer technologies, personalized genetic technologies, internet-based applications, and a number of other emerging technologies that will, and in many cases already are, used to promote public health or prevent, monitor or manage illness.

In Paper II we offer some insight into defining health technologies by using the results of the study to construct and present a categorical model for broadly sorting and understanding health technologies. The categorical model presented in Paper II is based on a relevant approach used by Cotterman and Kumar (1989), with a focus on perceived end-user control as a method for categorizing technologies. Here, technologies are categorized in terms of both the ways in which individuals access, and use, these technologies. In Paper II, technologies are broken down into three categories. The first type, direct end-user technologies (type 1), are technologies that are directly accessed and used by end-users (for example internet-based applications and consumer wearables). The second type, direct-use gatekeeper technologies (type 2), are technologies accessed by way of a gatekeeper but used by the end-user (for example prescription medications). The third, and final, type are

so-called indirect-use gatekeeper technologies (type 3) and are both accessed and used by someone other than the end-user (for example MRI). This categorization is illustrated in figure 1, below, and taken directly from Weiss et al. (2018).

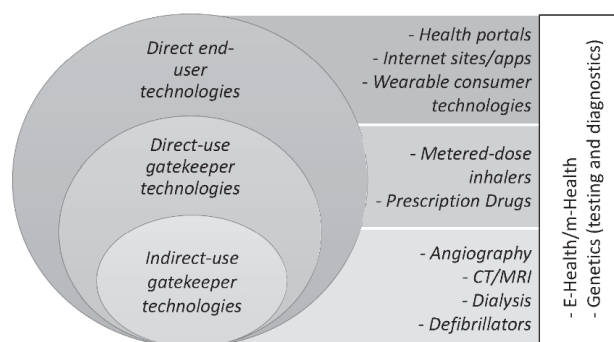


Figure 1: Classification of health technologies including a (non-exhaustive) list of example technologies (Weiss et al., 2018).

This classification emphasizes both the broad range of technologies that can be considered health technologies as well as suggests a broad range of mechanisms that influence the ways in which these technologies are both accessed and used, highlighting the complexity of universally defining health technologies. The results of the study also highlight, somewhat reflected in the model above, traditional medical sociological literature's focus on technologies that easily fit within the earlier definition proposed by The Office of Technological Assessment. This suggests an over representation of medical technologies (type 2 and 3 technologies) in the academic and scientific literature and an apparent underrepresentation of emerging, modern technologies for health (in large part type 1 but also type 2 and 3 technologies) that are marketed to a largely consumer-oriented customer base where individual agency and capital are central to questions of access and use patterns, and which are becoming increasingly important in debates surrounding public health and health equity.

The move away from a universal definition of health technology led to a more inductive approach to defining health technologies. Here, a flexible understanding has guided an exploratory perspective of health technologies, defined not by a priori expectations but by the emergence of technologies in contexts of public health. From this perspective, and possibly only from this perspective, has it been possible to move towards a comprehensive theory of health technologies in relation to broad socio-political implications, such as social inequality.

With an established understanding of *technology*, it is possible to turn attention towards defining *innovation*. Again, Rogers' definition of innovation is informative here. Rogers defines innovation as:

“an idea, practice, or object perceived as new by an individual or other unit of adoption” (Rogers, 2003).

Innovation, unlike technology, does not *require* the association of any physical object. It *can*, however, include, or even be itself, an object. Innovation does not need to be technological in nature but can also be, for example, informational, cultural, political, organizational or systemic. As O'Sullivan and Dooley (2008) highlight, innovation can be incremental or radical and can happen at all levels of an organization or society. Sveiby et al. (2012), in reference to a definition of innovation proposed by Van de Ven, emphasize that an innovation for one individual does not need to be experienced as an innovation for another (individuals first contact an innovation along various stages of the diffusion process – more on this in chp 2.1.2). O'Sullivan and Dooley (2008) furthermore establish that, although more specific definitions of innovation exist, often integrating elements of business and product development, in its most basic form innovation is simply the act of “making changes to something established by introducing something new.” Innovation is often confused with invention. However, while invention is associated with creating something that *is* entirely new (O'Sullivan and Dooley, 2008), innovation is simply something *experienced* as new. Innovation therefore does not need to include invention. It can, for example, be something objectively old but which is either modified or introduced in a manner that influences a subjectively innovative experience of that product, process, service, idea, organization, institution, or structure (either physical or cultural). Moreover, inventions have no inherent expectation to solve a social challenge or contribute social value, however this characteristic, it is often argued, is elemental for innovation, particularly technological innovations. This contribution to social value, however, often associates innovation with a potential for marketability or economic contribution (i.e. economic value or, simply, growth) (O'Sullivan and Dooley, 2008). However, a broad definition of innovation need not include this perspective and one could argue that innovation, understood in this way, is a forceful (and meaningful) abducting of the term by modern economics that does not appropriately fit with a broad sociological understanding of the term innovation as proposed by, for example, Rogers (2003).

Considering the above discussion, it is possible to propose a broad, functional definition of technological innovation in the context of social science as:

A design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome, which includes both a hardware and software component, and which is perceived as new by an individual or other unit of adoption.

If one were to incorporate the element of health into this definition one could then propose that an understanding of innovative health technology be defined as:

A design for instrumental action that reduces the uncertainty in the cause-effect relationships 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.

One could argue that it is namely a broad and comprehensive definition of innovative health technology, such as the one above, that fits best with both a broad sociological and social epidemiological (herein a societal perspective of population-level health, or public health) understanding of health technology that moves beyond simply defining health technologies as medical technologies confined to society's health care institutions (as has often been tradition in these fields) (Honjo, 2004, Casper and Morrison, 2010). Although this specific definition has not been explicitly outlined a priori to much of the work in this thesis, it incorporates all the elements of a general understanding of innovative health technologies that has grounded the work carried out throughout this thesis. It is therefore a working definition that can both be appreciated as a product of, and a useful tool to understand, the work conducted and presented in this thesis.

2.1.2 The diffusion of innovations

Rogers (2003) defines diffusion as:

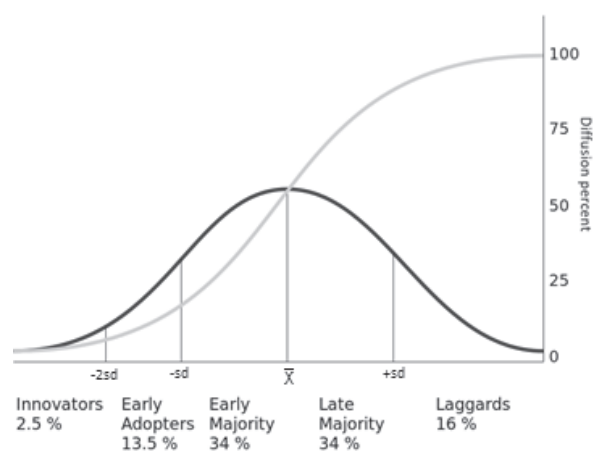
“The process in which an innovation is communicated through certain channels over time among the members of a social system.”

Herein we are interested in how *technological* innovations *in health* diffuse throughout the population and, in turn, what affect this has on health and inequalities. In other words, we are interested in the mechanisms that regulate and control adoption patterns of innovative health technologies by social groups based on SES, in order to understand in what ways these mechanisms contribute to potentially increasing or decreasing inequalities between these groups. Contrary to the idea of diffusion, which is interested in the spread of an innovation throughout a population, adoption is considered as the full use of an innovation by an individual. Therefore, one could say that diffusion is the spread of an innovation between adopters. The *rate of adoption* is the rate at “which an innovation is adopted by members of a social system” and is, therefore, a measure of diffusion (Rogers, 2003).

The principle underlying theory of the diffusion of innovations lies in its understanding of the mechanisms that determine the expression, and relative rate, of the typical diffusion S-curve

as well as this curves relation to categories of adopters distributed along the mean and standard deviation of a normal distribution of the total population. The idea being that, as the figure below illustrates, adoption rates (i.e. diffusion) are slow to start, beginning with innovators and early adopters.

Figure 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.



These groups tend to make up a relatively small portion of the population and therefore total adoption is also low at this point. However, as the majority of the population, represented by the early and late majority, adopt innovations, adoption rates (i.e. diffusion) increase. Adoption rates again slow as the laggards, again a relatively small portion of the total population and the last to adopt, adopt an innovation. The innovation eventually reaches 100% adoption (i.e. full diffusion) with this group and therefore results in a flattening of the diffusion curve (i.e. adoption rate = 0).

However, it is important to note that this diffusion curve is a theoretical ideal, representing an innovation that diffuses evenly and continuously and eventually reaches full diffusion. Not every innovation will follow this curve perfectly, and many will, in fact, never achieve full diffusion, being rejected by adopters somewhere along the diffusion process or even being replaced with a new innovation well before full adoption is possible (Rogers, 2003). Regardless of this fact, the trends that this curve illustrate, particularly in relation to the adopter categories that represent the different phases of the diffusion process and the

understanding that adoption rates can vary (the S-curve can be short and steep or long and relatively flat), are significant. Adoption rates, and therefore the rate of diffusion, are influenced by a complex network of factors (for more on this see chp. 6 in Rogers (2003)) however it is the aggregate rate of diffusion itself that has an enormous impact on the relative advantage that individuals in various adopter categories are able to exploit from the innovation – in this case by actually determining physical access to the innovation. An innovation that diffuses quickly is one whose benefits, in theory, become quickly available to a large portion of the population. In contrast, an innovation that is slow to diffuse results in the adopters of that innovation potentially accruing a relative advantage that can remain unavailable to a significant portion of the population for long periods of time. Although the details explaining the underlying cause of the rate of diffusion are themselves significant, the resultant rate of diffusion is itself an important social factor due to the fact that the individuals that constitute these adopter categories are not random but, instead, share important social characteristics. These social characteristics are also important for determining the relative advantage individuals in these adopter categories are capable of exploiting from an innovation even after adoption (in other words, relative advantage does not stop at adoption, but continues into use, even expressing itself with innovations that have potentially achieved full diffusion – see Paper II).

The significance of the social distribution of the characteristics of adopter categories lies in its connection with social position, status, and resource and power distribution. Diffusion of innovation research has highlighted that adopter categories share a number of personality traits and communication behaviors (Rogers, 2003). In summary, this includes increased average intellect and a greater acceptance for both risk and abstract, rational, scientific reasoning, as well as stronger, more outwardly-connected and information-rich social networks (Rogers, 2003). However, it is not just personality and communication characteristics that adopter categories share, but also characteristics of direct relevance to traditional understandings of social position or class. While age is not generally a stratifying variable for adopter categories, when compared to later adopters, earlier adopters are often more highly educated and more literate, enjoy positions of higher social status, experience higher levels of social mobility (in which innovations may actually be used to actively influence), and control or own larger sized “units” such as farms, businesses, etc. (i.e. a greater amount of material resource concentration) (Rogers, 2003). In other words, the characteristics that stratify individuals along the continuum of predisposition or intent to adopt an innovation have much in common with those that classify individuals by SES (for more on this see chp. 3.2). In fact, Rogers (2003) explicitly states that “these characteristics of adopter categories indicate that earlier adopters have generally higher socioeconomic status

than do later adopters.” This holds true not just for individuals as adopters of innovations in a system but also for organizations or institutions (suggesting important implications for, and an interesting connection with, the results of Paper IV). It is, of course, possible to question, however, the direction of causality in this relationship. In other words, to ask the question: do early adopters adopt innovations earlier because they enjoy positions of higher SES, or do they enjoy positions of higher SES because they adopt innovations earlier? The answer to this question is undoubtedly complex, lacking an orderly and straightforward explanation (i.e. causality is likely neither linear nor unidirectional), however the answer to this question is not necessary to recognize its general conclusion. The conclusion, namely, that earlier adopters, whether it be an individual, a private organization, or a democratic State, often enjoy positions of relative social advantage compared to later adopters, with significant implications for the distribution, concentration and potential (ab)use of this advantage across society.

There are a number of mechanisms presented by diffusion of innovations research that has important implications for the relative social advantage that these groups experience. As Rogers (2003) has outlined, early adopters of innovations often secure additional benefits that later adopters, simply by way of late adoption, are never able to access or exploit – often termed windfall profits or windfall benefits. Rogers often speaks of these benefits in economic terms, referring to the economic risk that innovators and early adopters are required to expose themselves to, providing economic returns generally unavailable in later stages of the diffusion process. The consequences of such a mechanism have resulted in Rogers (2003) asserting that “innovators become richer and the laggards become relatively poorer as a result of this process” leading to a “widening [of] the socioeconomic gap between the earlier and later adopters of a new idea.”

However, although Rogers recognizes windfall profits in economic terms, these benefits may come in various forms, including more symbolic social or cultural representations. As MacKenzie and Wajcman (1999) have highlighted, in referencing technological innovations, “success tends to breed success” and the early adoption of innovations tends to afford benefits to these innovations, and the agents that benefit from these innovations, that accumulate over time. Moreover, while early adopters of innovations tend to accumulate benefits unavailable to late adopters, late adopters are also more likely than early adopters to discontinue the use of previously adopted innovations (Rogers, 2003). This suggests, again, that relative advantage does not cease with adoption (full adoption is not synonymous with full equality) and that patterns of the use of innovations by various adopter categories also significantly influences the potential of innovations to (re)produce social inequalities, as we illustrate in Paper II and expand on in Paper III & IV.

As mentioned above, the social networks of high SES individuals, who are also often early adopters, tends to reinforce the early adoption of innovations. This is, in part, due to their contact with “change agents,” or individuals that influence a potential adopter’s innovation-decision towards adoption. In this sense, change agents can be seen as a type of ‘gatekeeper’ who creates opportunity for, and encourages, the adoption of an innovation for others. These change agents are of no particular occupational background, and can be, for example, scientists, teachers, government agency employees, or doctors or health personnel, but often possess a university education and some form of technical expertise (Rogers, 2003). In any case, change agents tend to communicate most effectively and most often with individuals of similar SES, or, in other words, individuals who tend to be early adopters of innovations. Furthermore, change agents tend to identify, possibly incorrectly, individuals of lower SES – and therefore often later adopters – as unreceptive to innovations and the efforts of change agents, encouraging a feedback loop that again limits their contact and effectiveness with late adopters (for further relevant discussions on health personnel as change agents reinforcing inequalities in relation to technological innovations in health, see Lutfey and Freese in chp 2.3 and Paper III).

Understanding these change agents as gatekeepers is particularly relevant for this thesis when one considers the importance this has in relation to the previous discussion in chp. 2.1.1 on defining technological innovations in health. The current discussions on change agent contact would seem to highlight the importance of the gatekeepers’ position in (re)producing social inequalities in the three-level categorization of technologies based on factors related to access and use presented in Figure 1 (see Paper II for more on this). It should, moreover, be noted that innovators themselves are gatekeepers. As the developers of ideas that become innovations, they have significant control over the flow of innovations into a presiding system (Rogers, 2003). The consequence of the above biased relationship between change agents and the eventual adopters of innovations results, importantly, in innovations tending to diffuse *across*, rather than *down*, social strata (Rogers, 2003)¹⁴. Ultimately, this paradox begs an important question: does this biased control over the flow of innovations into and across a social system consider to a greater extent the needs and desires of the earliest (high SES) or latest (low SES) adopters of innovations? Rogers (2003) has again provided some insight here, referencing research that supports the conclusion that change agents generally tend to “help those clients least who are most in need of their help” (a sentiment that seems to echo Hart’s *inverse care law* – see chp 2.2.1) and that “change

¹⁴ Although this may not be surprising based on relevant research around change agent contact, it should neither come as a surprise when one considers the theories of Pierre Bourdieu and his work on *habitus*, which would seem to support the idea that habits of innovation and adoption are patterned within, rather than between, social groups of varying SES – more on this in chp. 2.3.

agencies often cause increased socioeconomic inequality among their audience through their diffusion activities.” The answer to this question increases in importance when one, additionally, considers that relatively few diffusion studies are conducted on laggards or late adopters, instead favoring to study, and therefore also overly representing the needs, desires and characteristics of, innovators and early adopters (Rogers, 2003). The consequences of this research suggest that high status individuals, organizations and institutions don’t just adopt innovations earlier, and therefore accrue additional benefits from this early adoption, but also have much more influence in the early and continuous processes involved in the design, development and diffusion of innovations. Work by Castells on the new network society would seem to add further support for these conclusions, establishing technology’s potential to reproduce valuable social connections and therefore reproduce social domination and power on a global scale (for more see, for example, (Castells, 2013, Castells, 2007).

Although this is not a comprehensive illustration of the mechanisms that drive the diffusion of innovations, the above mechanisms are particularly important for illustrating the diffusion of innovation’s effect on social inequalities. It is possible to interpret the general patterns of change agent contact as a mechanism that reproduces general social inequalities, as valuable resources (i.e. technological innovations) and the skills to exploit them are shared, in large part, between individuals and organizations that benefit from relatively high social status. Moreover, and somewhat complimentary, windfall benefits could be seen as a mechanism that, in fact, contributes not just to the reproduction of general social inequalities but actually increases these inequalities over time, by accumulating benefits within high SES adopter categories.

The relationship between these mechanisms can be represented by the following simple equation. The (re)production of relative inequalities (let us call that rIE), in this case, is a product of the sum of windfall benefits (let us call that Wb), quality of change agent contact (let us call that qC , which is a product of both the amount and type of contact one has with change agents) and strength of the effect innovators and early adopters (i.e. high SES individuals) have over the design and diffusion processes of innovations (let us call that D), which is then moderated by the rate of adoption (let us call that rA). The equation would therefore appear as follows:

$$rIE = (Wb+qC+D)/rA$$

In this equation, high relative inequality would therefore be a product of windfall benefits (Wb) that are large, change agent contact (qC) that is of high quality, innovator and early adopters’ high strength of influence over development and diffusion processes (D), and a slow rate of

adoption (rA), all tending to favor high SES individuals. Although this equation is theoretical in nature, it attempts to illustrate the combined effects of the above mechanisms.

The diffusion of innovations theory, furthermore, draws attention to a social phenomenon that strengthens the importance and influence of the effects expressed in the above equation. The *pro-innovation bias*, or a bias towards favoring, or actively pursuing, the implementation and adoption of innovations across society, is, as Rogers (2003) himself concedes, “one of the most serious shortcomings of diffusion research.” This bias has underpinned much of diffusion research and unfortunately limited its scope, particularly in recognizing and understanding the potential for unanticipated and undesirable consequences of the diffusion of innovations. Rogers (2003) identifies some reasons for the presence of a pro-innovation bias in diffusion research, including the unfortunate reality that funding sources for diffusion research are often agencies that have a stake in positively representing innovations (in other words the funding agency bias pervades the resultant research environment) and, less deceptive but no less consequential, that successful innovations are often those innovations that present themselves as noteworthy subjects of scientific analysis.

However, although Rogers presents pro-innovation bias as a phenomenon embodied in the enterprise of science, others have recognized its presence and importance across sectors of society. This research highlights that the presence of a pro-innovation bias, not just in research but in society more generally, is not simply a result of the explanations mentioned by Rogers, above, but a more endemic sociohistorical event.

Over the span of the last 2500 years, innovation has undergone an enormous shift in its social standing. Based on its association with change, particularly in the social order, innovation has in past centuries been largely resisted by the religious institutions that have traditionally occupied society’s highest positions of sociopolitical power. To them, innovation was a form for heresy and, moreover, associated with political revolution (Sveiby et al., 2012). As late as the 20th century, academics and scholars in the social sciences were associating innovation with antisocial behavior (Sveiby et al., 2012). During the span of the 20th century, this meaning began to evolve, and innovation became increasingly associated with the introduction of useful, creatively inventive ideas and processes, ultimately resulting in a dominant association of much of its meaning with the creation of technological artifacts. The transformation of this meaning of innovation from one of negative connotations to one of positive connotations, was, in large part, supported by a partnership between agents of the State and agents of science, who interpreted the developing meaning of innovation – particularly technological innovation – as a tool in the service of both policy and industry (and, in effect, science, which is insofar inseparably related to both of these sectors of

society) (Sveiby et al., 2012). This transformation took root in political objectives focused on economic superiority and the competitive commercialization of dominant global markets while simultaneously grounding itself in the theoretical arguments of academic scholars (Rogers' *Diffusion of Innovations theory*, it could be argued, is an influential, albeit relatively socially sympathetic, product of this academic transformation). Innovation has, therefore, become synonymous with economic growth and has become largely inseparable from sociopolitical arguments legitimizing solutions to modern social welfare issues (Sveiby et al., 2012) – see Paper IV for more on this. In this sense, the term 'innovation' has become socially and politically 'neutralized' and, instead, has become an undisputed practice representing positive social characterizations, often associated with social good and social 'progress' (Rogers, 2003, Feenberg, 2012). Innovation has, in effect, become more than an idea, it has become ideology ("innovate or die" as some say, for example, or as is summarized in Sveiby et al. (2012), "discourses on innovation...produce innovation in the sense that they encourage people to innovate and then reward them. Discourses on innovation create the world of innovation").

This pro-innovation bias has, in turn, contributed to a decoupling of the responsibility for innovation from the responsibility for its consequences (Sveiby et al., 2012). However, as Rogers (2003) has indicated, it is often impossible to separate the desirable from the undesirable consequences of the diffusion of an innovation. Furthermore, Sveiby et al. (2012) highlight that current models forecast that long term effects of innovations generally lead to greater numbers of unanticipated, rather than anticipated, consequences. Therefore, although the desirable and anticipated consequences cannot be decoupled from the inherent effect of the undesirable and unanticipated consequences of an innovation, a pro-innovation bias drives agencies, organizations, and institutions responsible for the development and implementation of innovations to consider only the less frequent desirable, anticipated consequences of innovations.

This paradoxical attitude shares many similarities with debates surrounding *technological determinism*. Technological determinism understands technology in society as both autonomous and neutral (Feenberg, 2012). Technological neutrality assumes technological innovations as separate from society in that they are developed and implemented from a foundation of intrinsic disinterest. In other words, these innovations emerge largely as an idealistic means of providing solutions to natural individual and social needs. Moreover, technological innovation is seen as a process developing independent of human agency. In other words, social control on or over technological innovation is limited. Instead, technologies develop to independently deliver solutions to social struggles. However, this perspective results in an oversimplification, where one risks seeing technologies as "an

unchangeable ‘black box’” (Gabe and Monaghan, 2013). Furthermore, a perspective of technological autonomy supposes that the intentions of agencies and processes that drive the development and delivery of technological innovations are unaffected by the very social space that they inhabit. Society, in effect, has little control over the direction in which technological innovation shapes society even as society shapes technological innovation. This is a perspective that harks back to an uncritical view of technological innovation as a source of unquestionable social progress, where any question of the intentions and influence of technological innovation on society are seen as unequivocally ‘anti-technology’ (MacKenzie and Wajcman, 1999). However, one need only look to the history of the term ‘innovation’ referenced above to understand that technological innovation is an inherently political concept. In response, sociology, including the field of medical sociology, has offered productive alternatives to perspectives grounded in technological determinism, including the ‘technology-in-practice’ perspective offered by Timmermans and Berg (2003) and the ‘social shaping of technology’ offered by MacKenzie and Wajcman (1999). However, these contributions have had seemingly little effect on the popular socio-technical discourses grounded in an underlying pro-innovation bias, possibly due, at least in part, to the modern re-creation of sociohistorical, techno-cultural and economic discourses substantiating a positive view of technology.

But what makes pro-innovation bias dangerous (or at very least troublesome) is its largely implicit social presence, assumed yet unrecognized. It manipulates many of society’s daily decisions without revealing its presence. The result is a diffusion of innovations culture throughout society – including in sectors related to public health – that often uncritically and unquestionably accept that innovations, including technological innovations, are positive societal developments. These innovations, it is therefore presumed, have the right to, and often should be, adopted by society (which is again reinforced by scientific publications that are themselves grounded in a pro-innovation bias). This perspective leaves little room for – in fact often actively stifles – critically understanding the potentially significant consequences of the development and implementation of technological innovations. Possibly more important for society, however, this perspective leaves little room for a constructive understanding of the underlying mechanisms that result in innovations effectively serving society. Left unrecognized, these consequences ultimately undermine the aggregate social value of innovation across society¹⁵ (Sveiby et al., 2012).

¹⁵ Some of the most important challenges society faces today are a result of historical technological innovation (climate change for one). It would, in any case, be naïve to think that innovations cannot and will not be a central part of meeting and overcoming these challenges (as they also have in the past), but it would be equally naïve to ignore the fact that our innovations are not also instigators of significant social and natural destruction and suffering (see the *Afterword* for more on this).

In response to the overwhelming effects of a pro-innovation bias, Rogers (2003) has, in fact, exclaimed that the sciences are in need of “a number of diffusion researches with an ‘anti-innovation bias’ in order to correct for past tendencies.” This thesis, importantly, has no intention of being ‘anti-innovation’. It does, however, make explicit attempts to address the importance of understanding innovation and technology from a balanced scientific and socially relevant perspective with respect for the unanticipated and often socially undesirable consequences of technological innovation. It is apparent that too little research has adopted this perspective (Sveiby et al., 2012, Rogers, 2003). The need for a critical (maybe a better term here would be *questioning*) perspective of innovation, and in particular technological innovation, is not an attack on technology or innovation. Rather, it is a perspective grounded in the neutral scientific understanding of the full spectrum of influence that innovation and technology have on the social space, herein in relation to social inequalities and public health. Although it is arguable, the fields of, and related to, technology development may bear no social responsibility for the critical evaluation of innovation and technology (although this does not, of course, render the consequences less likely or damaging). However, a balanced scientific perspective cannot exist in the assumption that innovation and technology are unquestionable social goods (i.e. a pro-innovation bias). In other words, and in the spirit of Bourdieusian reflexivity, *a science which falls victim to the very biases that it is responsible for revealing is no science at all*¹⁶.

Therefore, any science interested in understanding the ways in which technological innovations in health influence social inequalities must recognize that scientific investigation has indicated that the diffusion of innovations inherently “widen[s] the socioeconomic gap between the audience segments previously high and low in socioeconomic status” (i.e. between early and late adopters) (Rogers, 2003). Furthermore, the disregard for recognizing the consequences of technological innovations is often a product of socially distributed inequalities in power, where innovations often bestow positive economic returns for powerful stakeholders (innovators and change agents) while negative consequences are passed on to less powerful stakeholders and passive adopters of innovation (Sveiby et al., 2012). Only after recognizing this can science begin to understand the underlying mechanisms that contribute to the very real, but often unrecognized, social consequences of the diffusion and adoption of innovative technologies (in health, for example) and offer evidence in support of moderating the effects of these often unanticipated and generally undesirable consequences (such as reducing social inequalities).

¹⁶ Italics here are my own and intended, in good faith, to emphasize the subjectively appreciated importance of this statement.

2.2 SOCIAL INEQUALITIES IN HEALTH AND THE THEORY OF FUNDAMENTAL CAUSES

2.2.1 An intellectual evolution

The study of social inequalities in health has been historically dominated by a branch of epidemiology that has traditionally been concerned with addressing the social distribution of health and its determinants, what has been designated as *social epidemiology* (Honjo, 2004). Honjo (2004) has elegantly summarized this field's theoretical understanding of the distribution of health and disease as a reflection of "the distribution of advantages and disadvantages in that society" and "based on this premise...examines which socio-structural factors affect the distribution of health and disease, as well as how these factors influence individual and population health." It is from this field's scientific approach that Julian Tudor Hart in 1971, during the formative years of modern social epidemiology, published his discovery of the aptly named 'inverse care law'. This law has formed a pragmatic point of departure for much of social inequalities in health research. The law, quite simply, states that "the availability of good medical care tends to vary inversely with the need for it in the population served" and goes on to highlight that this effect is intensified where market forces are most influential (Hart, 1971). Full bodies of research have and still lend support to Hart's law of inverse care. As a recent example, Fjær et al. (2017) illustrated that the use of health care services is distributed unevenly in European society. With individuals categorized on the basis of a number of variables measuring socioeconomic position (SEP) and based on relevant findings that low SEP individuals tend to suffer from poorer health and therefore greater demand for health services, Fjær et al. (2017) discovered that low SEP groups were less likely to use specialist services even in countries where they overrepresented use of general practitioners (GP). Moreover, in countries where they underrepresented use of GP's, these inequalities were again reflected in the use of specialist services. This study clearly represents both the modern relevancy of the social (or *sociological*) epidemiological field of studying inequalities in health as well as the relatively modest – at least in some societies – progress in combatting these inequalities over the past 50 years since Hart's inverse care law was first published.

The field of social epidemiology has a deeper history than that which came in the years following Hart's inverse care law, however. The idea that social conditions affect health is nothing new, but science did not begin to officially establish and verify this connection until the 19th century. In Europe, during the early half of the 19th century, various researchers in countries such as France, Germany and Britain began experimenting with the idea that these social conditions significantly affected the prevalence and distribution of illness and disease (Honjo, 2004). During this time, Virchow has even speculated that the unequal access and

distribution of society's products was a fundamental cause of health inequalities (Honjo, 2004) – a statement that is interesting when considering that it took more than a century before social epidemiology would see Link and Phelan (1995) propose a theory by the same name (i.e. *Fundamental Cause theory*, which will be discussed in detail below). The late 19th century and early 20th centuries marked the arrival of germ theory and a public health practice focused on combatting infectious disease. The 'social' was once again largely overlooked by the field of epidemiology and, instead, replaced with a focus on individual risk factors. It wasn't until modern medicine gained relatively comfortable control of infectious disease that attention began to increase for the spread and control of chronic disease, and perspectives around public health once again began to turn towards the 'social' – producing theories such as Hart's inverse care law. The 1970's and 80's led to a solidification of the 'social' in the field of epidemiology and marked the beginning of modern social epidemiology.

Many of the theoretical and empirical perspectives grounding modern social epidemiology, and what many refer to as a marker of the field's official coming of age, coincide with the Black Report. Released in 1980, the Black Report was an official state document outlining the condition of inequalities in health in Britain. It contributed to increasing attention, not just in Britain but internationally, on the effects of socioeconomic factors in determining the distribution of health in society (Lahelma, 2001). In the years that followed, social epidemiologists, such as Sir Michael Marmot, in turn led the charge in this direction, drawing increased attention to empirically testing, monitoring and eventually combatting what they saw as the moral imperative to reduce socially produced inequalities in health. Michael Marmot's work has been hugely influential in this area, permeating much of the scientific and political literature, particularly in Europe but also intercontinentally. Although his work has made major contributions to the theoretical and empirical understanding of health inequalities, he has not been alone. A number of empirical models from this period of research now underpin much of the continuing field of social inequalities in health.

One of the central pillars of modern inequalities in health research is that of the social gradient in health. The social gradient in health is an illustrative model of the distribution of health throughout society. It is the result of many years of empirical findings that illustrate what one could argue is the transfer of the central principle of Hart's inverse care law – health care is inversely correlated with need – to a comprehensive social perspective focused on population health. The central findings of the social gradient in health illustrate that mortality, and often general health, is inversely related to an individual's position in society (Beckfield et al., 2013). Although this may sound intuitive – that individuals rich in valuable social resources (i.e. capital in all its forms) enjoy better health than individual's poor in these resources – the significance of this finding is in the model's illustration of this

inverse relationship across *all* social position. In other words, the gradient is an inverse, and linear, relationship that permeates every level of society, from the poorest to the richest. The result is that no matter an individual's SES, individuals with higher SES will have better health and individuals with lower SES will have worse health (on average). Marmot (2018) summarizes the gradient as “a graded association between an individual's position on the social hierarchy and health” which extends “from the highest echelons of society to the lowest” and which results in inequalities that he has argued, as have others, “threatens social cohesion.” The fact that these inequalities are systematic (i.e. frequent and persistent) and unfair (i.e. socially constructed) make them particularly interesting for social scientists (Mackenbach, 2012, Braveman and Gruskin, 2003, Beckfield et al., 2013). The inequalities represented by ‘the gradient’ have been argued to be, contrary to other unavoidable or natural inequalities, a matter of social equity with deep moral and ethical obligations (Braveman and Gruskin, 2003).

At the same time that research began establishing the presence of a social gradient in health, various scholars attempted to provide structural models to explain the existence of this gradient. Out of this research arose a model that came to dominate the field of inequalities in health research (and in many ways still dominates, although a number of contemporary models have gained strength to compliment or challenge this model). This model is the social determinants of health perspective first proposed and, later, expanded on by Dahlgren and Whitehead (1991). The model is characterized by its rainbow illustration (figure 3 below) outlining an array of determinants considered to be central in producing and distributing health throughout the population at various levels of society. The social determinants are considered by many to be an explanation of the production and distribution – i.e. the ‘causes of the causes’ – of health in society based on fundamental “conditions in which people are born, grow, live, work and age” (Braveman and Gottlieb, 2014).

Figure 3: Social determinants of health, adapted from Dahlgren and Whitehead (1991)



The influence of this model is exemplified by its official adoption by the World Health Organization (Wilkinson and Marmot, 2003, Marmot et al., 2008). The perceived value in the model has largely been its apparent ability to not just explain the social production of health but also to contribute a social and political imperative for promoting public health and tackling (i.e. reducing) social inequalities in health. Largely based on the social determinants of health, widespread international recommendations for policies to reduce inequalities in health have been pushed by powerful governments and international agencies, however with mixed results (Marmot et al., 2008, Marmot, 2015, Braveman et al., 2011). Regardless of the influence that the social determinants of health have had on public health policy internationally, inequalities in health have proven to be remarkably persistent, even demonstrating significant increases in many countries over the last few decades (coinciding with the dominance of the social determinants of health perspective) (Mackenbach et al., 2016, Mackenbach et al., 2008, Beckfield et al., 2013, Braveman et al., 2011). Although this does not necessarily undermine the contribution of the social determinants of health model, it does, however, suggest an imperative to more comprehensively understand and explain mechanisms that contribute to the persistence of contemporary social inequalities in health.

These central developments, and a general solidifying of theoretical and empirical practices, within the field of social inequalities in health has also contributed to a number of scholarly discussions focused on central terminology, including the very definition of health. Although a full history of debates surrounding the meaning of health are too comprehensive for the scope of this thesis, there is an important distinction in the field of public health research that has been enormously influential in shaping the way the field approaches topics of

inequalities. The early social epidemiological years, very much influenced by a tradition in the medical (i.e. clinical) sciences, often defined health as the absence of disease and illness. This perspective was poorly accepted by some scholars and practitioners, who believed that good public health was heavily influenced by social factors and a result of promoting population health rather than population-wide efforts to treat individual health. Although the World Health Organization had offered an intentionally contrasting definition to this traditional definition of health, referring to "...a state of complete physical, mental and social well-being and not merely the absence of disease..." (McCartney et al., 2019), this definition proved to be controversial as well, with many citing its overly absolutist (some say unrealistic) reference to health as "complete" well-being.

With the help of influential sociological scholars such as Aaron Antonovsky and his theory of salutogenesis (a deliberately opposing view to the dominant medical perspective of pathogenesis – *patho* being the Latin root for disease, and *saluto* being the Latin root for health), the academic definition of health underwent a reformation. Based on the inspiration of many of these debates, the World Health Organization extended their definition of health in the Ottawa Charter of 1986, to, based around their original definition, include elements of control, coping, cross-sectoral responsibility and health "as a resource for everyday life, not the objective of living" (McCartney et al., 2019). More recently, many years of debate have led McCartney et al. (2019) to propose yet a new, no less ambiguous, definition, considering health to be "a structural, functional and emotional state that is compatible with effective life as an individual and as a member of society." In any case, the transformation of definitions of health since the mid-20th century have been importantly influenced by an academic shift inspired by, and no doubt resulting in, the social determinants of health perspective. Health in contemporary public health literature is, therefore, often understood, as it is in this thesis, as a valuable resource that is at least as much a socially constructed experience as an individual one. These discussions, however, are far from concluded and many still debate the central definition of health and its influence within the field of social epidemiology, public health and medical sociology.

The paradigmatic shift in focus firmly incorporating the 'social' in epidemiology and public health has both opened new space for, and been inspired by, a coinciding growth in the sociology of and in medicine (Gabe and Monaghan, 2013). As a result, the interdisciplinary collaboration of social epidemiology and sociology have largely been responsible for producing contemporary inequalities in health research. This interdisciplinarity – with a shared goal of understanding and explaining the materialization and persistence of social inequalities in health – has resulted in various models proposed as potential explanations. The theoretical and empirical strength of these models have offered the health and social

sciences various degrees of influential advances in explaining inequalities in health while simultaneously contributing new grounds for continued debate (Kawachi et al., 2002) – see also Mackenbach (2012) for a more detailed presentation and discussion of these various explanations. Regardless of these debates, over 50 years of advancement in the fields of social epidemiology and medical sociology have resulted, ultimately, in a paradigmatic shift drawing increased attention to a ‘social’-ized understanding and practice of medicine and public health. This development has, in turn, contributed to a dominant discourse within relevant academic and political domains largely transferring the burden of responsibility for public health from the individual to society (a shift with important implications when considering the future of technologies and inequalities in health – for more on this, see chp 5.3).

2.2.2 Identifying ‘fundamental causes’

Due to the persistence of inequalities in health across nations and an apparent need to better understand this persistence to more effectively combat and reduce these inequalities, contemporary scholars have attempted to move beyond the social determinants of health model. The growing literature has largely solidified the field of inequalities in health research and led to a more nuanced, interdisciplinary debate of the methods used to measure, and the mechanisms in society that (re)produce, these inequalities.

Mackenbach (2012) has offered an overview of many of the dominant complimentary or contesting theories that have developed jointly, independently, or as a response to the social determinant’s perspective. Outlining these theories is a contribution to the development of a comprehensive explanation to the paradoxical finding that generous welfare states do not necessarily present lower inequalities in health regardless of policies that would be assumed to alleviate these inequalities. Theories range from social inequalities in health simply being the representation of a ‘mathematical artifact’, to inequalities being represented by ‘personal characteristics’ or the ‘social selection’ (i.e. sorting) of individuals with good health and valuable characteristics to higher socioeconomic positions (i.e. reversing the causal direction). Other theories focus on cumulative effects of long-term exposure to deprivation or stress (‘psychosocial pathways’) over the ‘life course’ or the representation of existing inequalities in various forms of valuable capital such as material resources (‘neo-material factors’) or ‘cultural capital’. However, the ‘diffusion of innovations theory’ is also highlighted as a theoretical explanation based on the unequal adoption of innovative behaviors (the paper mentions nothing of material innovations or technologies as they relate to this theory). Furthermore, Phelan and Link’s (2013) Fundamental Cause Theory (FCT) is presented as a general, unifying theory that understands inequalities in health as a result of the unequal distribution of various forms of both material and symbolic resources. Similar to the diffusion

of innovations theory, the FCT posits that inequalities in health will be reproduced as long as new opportunities for preventing illness or promoting health (i.e. innovations) exist.

Although the FCT has gained popularity with many scholars, particularly in the medical sociological sciences, Mackenbach (2012) argues that the FCT is simply “an elegant reformulation of the problem”, with little explanatory power for the specific mechanisms connecting health and SES. It would seem as if the FCT does little to move beyond the social determinants of health perspective, as both succeed in drawing attention to the ‘causes of the causes’ by highlighting the relative importance of specific resources in society that are beneficial for creating and maintaining health. However, Mackenbach (2012) also admits that FCT’s usefulness is in its ability to draw attention to “fundamental aspects of social stratification”, something the social determinants perspective does poorly. While the social determinants of health perspective effectively presents a broad overview of valuable resources in society that (re)produce health (such as education, working and living conditions, etc.), it does little to integrate perspectives that succeed in acknowledging mechanisms that persistently (re)produce inequalities in health throughout society (i.e. imbalances in power and the distribution of resources such as financial and cultural capital). The FCT, on the other hand, is grounded in a theoretical understanding of mechanisms of social stratification that unequally (re)distribute the resources that (re)produce health. In other words, while the social determinants of health is a valuable theory for understanding the (re)production of health in society, the FCT moves beyond this perspective to offer a valuable theory for understanding the (re)production of health *inequalities* in society. In the decades-long search for a comprehensive theoretical foundation to explain the ‘causes of the causes’ of social inequalities in health then, it is not surprising that the FCT is seen as a valuable theory for moving theoretical and empirical perspectives ‘upstream’ and beyond the social determinants of health – a likely reason for much of the FCT’s growing academic popularity over the past couple decades.

The FCT’s central assumption is that valuable ‘flexible’ resources “such as knowledge, money, power, prestige, and beneficial social connections” are deployed by individuals “to avoid risks and adopt protective strategies” against disease, illness and mortality (Phelan and Link, 2013). The dominant socio-economic structure that allows individuals to unequally access and exploit these ‘flexible’ (i.e. dynamic) resources, leads to inequalities in population health regardless of the diffusion of medical advances – explaining the persistence of these inequalities across time and space. The theory has, in part, been a response to what the authors believe is epidemiology’s continued overemphasis on ‘proximal factors’ (i.e. not enough focus on deep social mechanisms), while simultaneously attempting to offer a theory

explaining the persistence of social inequalities in health internationally (Link and Phelan, 1995).

The theory has been tested on a number of occasions. Link et al. (1998) illustrated that SES-based inequalities in cancer mortality (breast and cervical) were low or non-existent before the advent of relevant screening techniques however, after the implementation of these screens, SES-based inequalities in mortality grew significantly, supporting the theory. Using another method to test the theory, Phelan et al. (2004) demonstrated that SES-based inequalities in mortality are significantly higher for 'preventable' vs 'non-preventable' causes of death, or in other words causes of death that are "more amenable to the application of flexible resources". These results were once again supported by similar findings from a study published in 2005 (Phelan and Link, 2005). Furthermore, the interest in this theory has led several other researchers to conduct similar tests of the theory, which Phelan and Link have summarized in their paper from 2013, with results often seeming to support the theory's central assumption (Phelan and Link, 2013). However, these seemingly encouraging tests of the theory have not prevented researchers and scholars from being critical of the theory.

Øversveen et al. (2017) elegantly address many of the central critiques of the FCT. Critiques include, for example, an overreliance on an assumption of linear causality running from SES to health. In other words, the FCT assumes that SES provides opportunity for resource procurement that, in turn, offers opportunity for (re)producing good health at the individual level. However, the theory does little to address the possibility that this causal chain is neither linear nor unidirectional and, instead, that SES can also be influenced by the access to, and exploitation of, valuable resources or existing good health. Furthermore, FCT has been criticized for a perspective overly emphasizing the strength of individual agency. The FCT assumes, explicitly in its statement of its central hypothesis, that individuals avoid risk factors by actively "deploying" the resources that FCT assumes are responsible for strongly influencing health outcomes. The assumption of 'deployment' seems to leave little room for balance in an age-old sociological debate between agency and structure, where Link and Phelan seem to assume that agency determines outcomes. This assumption may, furthermore, appear out of place in a theory that is simultaneously focused on the deep structural mechanisms that reproduce stratification and inequality in society (i.e. a structuralist approach)¹⁷. Moreover, FCT has traditionally assumed that an equal redistribution of resources in society will inherently result in a reduction of inequalities. However, as Freese and Lutfey (2011) have highlighted, there is no substantial evidence to

¹⁷ As traditional dualism debates illustrate, and Øversveen et al. (2017) highlight, a plausible resolution rests in acceptance that "neither agency nor structure is given causal primacy" but instead "are seen as mutually interdependent processes, shaping social life".

assume this to be true. Inequalities may still exist as a result of, for example, unique preferences between socioeconomic groups. Lastly, the FCT and its empirical tests have largely relied on data and analysis based in the United States. This presents limitations to generalizing findings internationally, where, for example, health care system models, demographics, trends in existing inequalities, dominant cultural practices, and influential social welfare policies may differ greatly. However, this has not stopped sociological and epidemiological scholars from increasingly integrating the FCT and its conclusions into theoretical explanations of inequalities in health outside of the North American context in which the theory has largely been developed and refined. It would seem, then, that the theory is in need of empirical testing under various international political and cultural contexts that may challenge or reinforce the central assumptions of the FCT. In Paper III we have attempted to build on (and test) some of the underlying assumptions of the FCT in a Norwegian context.

Due in large part to some of the criticisms above – leading Freese and Lutfey (2011) to, somewhat tongue in cheek, summarize FCT’s central explanation as “people of higher SES benefit more because they benefit more” – academic contributions have been made in an attempt to improve FCT. To this end, Freese and Lutfey (2011) have offered an explanation of additional “metamechanisms”. First, “spillover effects” are explained as effects garnered unintentionally by individuals as a result of contact with other individuals, and environments, characterized by similar SES. In other words, if higher SES individuals, and the environments they produce as a collective, tend to promote health to a larger degree than those of low SES, than simply by occupying a position of high SES one garners health benefits. Furthermore, ‘habitus’ offers an explanation for potential SES-based variations in preferences for health improving behavior or outcomes. Habitus – a form of ‘socialization’ – posits that, although SES appears to determine the health status of an individual, it is possible that preferences of that particular group influence health status independent of resource access or acquisition. The attainment of good health is of course not the only, or highest, goal of all individuals in society (even if researchers of public health sometimes assume so). So, therefore, increasing this groups availability to resources would not necessarily eliminate inequalities in health. Although this contribution to the FCT allows for a more nuanced understanding of the mechanisms at play, Freese and Lutfey (2011) are themselves aware of the danger this perspective poses to inappropriately shifting responsibility to the individual (i.e. “blaming the victim”). It may be equally safe to assume that these predispositions – or mechanisms of within-group socialization – are themselves created as an unconscious response to cultural and political forces that symbolize positions of more or less advantage in society. Lastly, Freese and Lutfey (2011) draw attention to

institutions as a metamechanism. Although public institutions, such as schools, places of employment and hospitals, may be a resource that can be used proactively to improve outcomes related to health, these institutions are also settings and environments that have the potential to (re)produce inequalities. While the FCT often assumes these institutions as static resources either accessed and used by individuals to improve health (by high SES individuals, for example), or not accessed and therefore not used by individuals to improve health (by low SES individuals, for example), institutions themselves are not neutral. As Lutfey and Freese (2005) have illustrated, this form for 'institutional agency' may have the potential to undermine, or act regardless of, individual agency, to reproduce inequalities in the way individuals of various SES experience these institutions, significantly effecting the results of these interactions. Inequalities may be unknowingly reinforced by agents of these institutions that experience high status individuals as 'ideal' users of the services of that institution. A teacher or principal at a school may, for example, unconsciously reinforce social inequalities by offering opportunities to high SES students unavailable to low SES students based on a socialized perception of merit or motivation that is a product of SES-based advantage rather than a true representation of merit or motivation. Therefore, a focus purely on access to these institutions as a result of individual agency may hide inequalities in their lived experience, or use, as a result of institutional agency (Paper II and III offer more in-depth discussions related to institutional agency and questions of access vs use.) Note, importantly, that none of the metamechanisms outlined by Freese and Lutfey (2011) above are necessarily a result of purposefully deploying 'flexible' resources in an attempt to actively improve health or reduce the risk of disease (i.e. individual agency), as is assumed by the FCT.

Although the above contributions have led to a significant refinement of the FCT and increased its potential for practical application, this theory is still in its relative infancy and has the potential to benefit from both a contribution to, and further developed by, an integration with other powerful sociological and epidemiological theories. Phelan and Link (2013) mention that FCT is a middle-range theory that, according to them, "must join with other theories to account for the social distribution of health and illness." Further integration and development has the potential to contribute to more comprehensive explanations of the persistence of modern inequalities in health. Therefore, the power of the FCT may not be in its potential as an ultimate, unifying explanation of the persistence of these inequalities but, rather, in its ability to offer theoretical and empirical substance to a number of other subfields attempting to illuminate specific mechanistic pathways that (re)produce, and therefore result in the persistence of, inequalities in health. One such example may be the development and adoption of increasingly important technological innovations in health.

2.3 THE DEVELOPMENT OF A GRANDER THEORY

2.3.1 Fundamental causality and innovation

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 health care (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 reduces 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), in fact, 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 combining 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

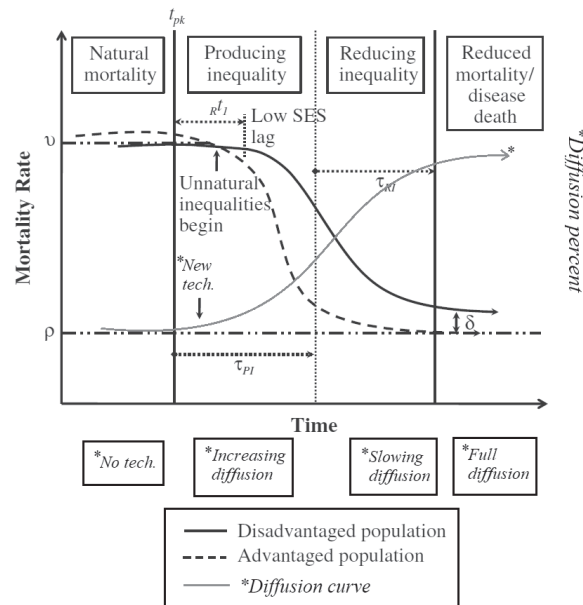
diffusion process of this technology followed a socioeconomic gradient. In other words, high SES individuals showed significantly faster adoption rates for some of these technologies, increasing inequalities in associated health outcomes, and leading them to conclude that the results were consistent with Hart's (1971) inverse care law. The value of this study is in its ability to illustrate the importance influence of rates of diffusion (of innovative technologies) has on associated inequalities. However, it is Chang and Lauderdale (2009) (and possibly *only* Chang and Lauderdale) who *explicitly* incorporate FCT and the diffusion of innovations theory into 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 (see Paper II for a more complete overview of relevant studies). 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 figure 4, below. However, in figure 4 a traditional diffusion of innovations curve has been included (additions marked with an *).

Figure 4: “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 Clouston et al.’s (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 x-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 1960’s. 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 (see, for example, Paper III's explicit integration of FCT and diffusion of innovations theory into the beginnings of an empirical framework for testing, and further developing, these theories as they relate to 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.

2.3.2 Technology as 'symbolic' capital

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 (Bourdieu, 1986, Wacquant, 1998, Fries, 2009). 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, Fries, 2009, Wacquant, 1998). 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 could 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* (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 (for example 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 vs 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 interpreting 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 (as discussed in chp. 2.2.2) 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, as discussed in chp. 2.1.2. 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 often affords an individual with the opportunity to become aware of the possibility of personal genome sequencing early, by way of valuable social connections and a heightened awareness of developments in science and business, as well as gain access to and exploit the potential of personal genome sequencing, by way of economic purchasing power and contact with institutions and organizations that provide these services. Although, as with the diffusion of innovations theory, it is assumed that groups in positions of lower SES will eventually follow into these openings, 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 Bourdeusian 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 lends 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 (as this thesis in part illustrates), 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 (i.e. economic growth, with all its promises for social welfare – see chp. 2.1.2 and Paper IV for more discussion on this) (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 (more on this in chps. 1.2 and 2.1.2).

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 (as this thesis defends). 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, refer to discussions in chp 2.2.2 and Paper III) 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, see chp. 3.2.1) 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.

3 METHODS & DATA

3.1 DATA SOURCES

3.1.1 Survey and register data

Survey data in Nord-Trøndelag

The Nord-Trøndelag Health Study (HUNT) is a county-level public health study started in 1984 with the objective of surveying and measuring the health of the entire county's adult population (≥ 20 years of age). The study includes a general questionnaire as well as targeted questionnaires, clinical observations and interviews, and the collection of biological material (including DNA), in areas such as diabetes, hypertension, lung disease and various cancers. The survey's database currently includes data from three cohort panels during 1984-86 (HUNT 1, N=77,212 or 89% of those invited), 1995-97 (HUNT 2, N=65,237, 69.5%), and 2006-08 (HUNT 3, N=50,807, 54.1%) (Krokstad et al., 2012). The survey provides a total of 166,758 observations available from 97,251 individuals who have answered either one (n=48,414), two (n=28,167), or all three (n=20,670) of the surveys (Vikum et al., 2013). The HUNT Research Center, as of spring 2019, is collecting data for a fourth cohort panel.

Variables included from the HUNT study focused primarily on the use of diabetes technologies. This included various home-based methods of urine and blood sugar measurement using both analog strips and digital readers, as well as various home-based methods of insulin injection including the use of syringes, pens and pumps. The use of laser eye treatment was also included as well as clinical measures, such as length of illness (diabetes), and demographic data such as age and gender.

Norwegian population register

Statistics Norway (SSB), provided socioeconomic information (education and income). SSB is the national producer of official population-based statistics in Norway, including those for health, education and economics at national, regional and local levels.

Included from this registry were variables of pensionable income data, as the sum of personal income for each year from 1984-2008, as well as level of education – here categorized as low (lower secondary schooling), medium (upper/post-secondary schooling) and high (university education) – based on the National Standard Classification of Education in Norway (NUS) system during the period 1984-2008.

3.1.2 Political documents

Parliamentary documents as well as government-sponsored reports and planning and strategy documents from government agencies including the Norwegian Health Directorate and the Norwegian Directorate for e-Health. These types of central strategic government

planning documents – such as white papers – as well as government reports and specific plan and strategy documents have traditionally been influential in the lawmaking procedure and therefore provide valuable insights for analyzing government discourse (Wodak and Meyer, 2009).

3.2 METHODOLOGICAL PERSPECTIVES

3.2.1 Measuring social inequalities (in health)

Academic debates have deliberated at length over the proper use of the term inequality vs inequity. In general, distinctions between these two terms are understood as a product of their inherent implications for social fairness and human rights. Inequity is often misunderstood as synonymous with inequality, however although both terms can be used to refer to variations in health in a population (i.e. *health inequality* and *health inequity*) inequities differ in that they are generally considered unfair or unjust. Defining specific inequalities as unfair or unjust, however is far from simple, particularly for science and academia. Kawachi et al. (2002) have emphasized that “because identifying health inequities involves normative judgment, science alone cannot determine which inequalities are also inequitable, nor what proportion of an observed inequality is unjust or unfair.” However, this does not imply that many of the inequalities addressed in academic literature are not also unjustly and unfairly distributed throughout the population. In fact, many of these inequalities, also those discussed in this thesis, are of particular significance for human rights and social justice. Moreover, the academic literature is also often interested in inequalities that present themselves as socially persistent and consistent (i.e. systemic) (Braveman and Gruskin, 2003). This criterion underpins the theoretical and methodological perspectives of this thesis. It is important for this research to highlight trends that are demonstrated, or expected, to be both persistent and consistent across the social hierarchy (again, one may refer to the ‘social gradient’ here) and within and between various social contexts. This objective is therefore largely grounded in methods of analysis using robust institutionalized understandings of (often unjust) social disparities such as those that exist between levels of education and income (Kawachi et al., 2002).

Science generally divides the variables typically used to measure social position, and investigate systemic social inequalities in health, into three overarching categories. The first, and most common, perspective understands social position as the sum of a complex network of relatively amenable, flexible resources available to individuals (largely embodied by the FCT – see the discussion in chp. 2.2 for more) (Phelan and Link, 2013). Much of social inequalities in health research has based analyses on this perspective, relying heavily on using measures of SES to understand and measure an individual’s position in the social

hierarchy. Traditionally, this has been done using various scales that categorize education, income and occupation. As Mackenbach and Kunst (1997) have appropriately highlighted, “SES refers to an individual's relative position in the social hierarchy and can be operationalized as level of education, occupation and/or income.” However it would be incorrect to assume that these measures of social position can be used interchangeably, as each of these measures not only present unique methodological strengths but also influence health by way of distinctive mechanisms (Braveman et al., 2005).

Education, for example, is possibly the most common measure of SES and, although it has proven to be very useful in health inequalities research, it is not without its limitations. Importantly, education represents, to various degrees, both material and non-material resources, such as prestige and health-related skills including numerous levels of literacy (for example, health, digital, functional, legal, etc.). In addition, education level is generally a very stable measure of SES in adulthood, as it rarely changes over the adult life-course (the opposite would obviously be true for the early life-course up to adulthood), and comprehensive datasets are often more easily accessible than for other measures of SES, such as income (Braveman et al., 2005). Moreover, education is less prone to issues of reverse-causality, where health status may be as likely to explain level of education as level of education is to explain health status, at least in adulthood. For these, and other cultural, reasons, education remains a valuable determinant of both income and occupation in various international contexts, including Europe (Lahelma, 2001). However, using level of education as a measure of SES can be challenging across countries or generations as its relative importance in society can change over time or between cross-national socio-cultural contexts. Furthermore, simply measuring years of schooling poorly captures real differences in the quality or symbolic importance of schooling, which may have important impacts on health (Lahelma, 2001, Beckfield et al., 2013, Braveman et al., 2005).

Income is also a widely used measure of SES in health inequalities research, as it is an important predictor of health outcomes and is a valuable measure of material resources (Lahelma, 2001, Beckfield et al., 2013). However, income is a less stable measure than education, as it remains fluid and dynamic, with the possibility of shifting many times throughout the life-course. These changes in income, if great enough, may have important implications for health that may not be well represented by measuring SES at a single point in time (which is common in health inequalities research). Furthermore, the problem of reverse-causality, referenced with education above, becomes a much more relevant issue for income as it is not always clear the relative degree to which either income influences health or health influences income.

Lastly, occupation is often used as a measure of SES or social position. In comparison to education and income, occupation is most commonly characterized as a representation for *social class*. The dominant model for categorizing individuals in accordance with occupation is the Erikson-Goldthorpe occupational class schema (Erikson et al., 1993). Although occupation displays strong associations with diverse health indicators (Braveman et al., 2005), it only functions well for those sectors of society that are actually employed and is, again, also limited by issues of reverse-causality (as discussed above for education and income) (Lahelma, 2001).

The second, also common but less prolific, categorization of methodologically classifying social position relies on a perspective based on fixed (or ascriptive) factors. These studies generally focus on using variables such as age, gender and/or race/ethnicity. Although age and gender are commonly included in studies of social inequalities in health they are most commonly included as confounding factors and controlled for, rather than variables central to the analytical model (i.e. dependent or independent variables). Race and ethnicity, on the other hand, have a long tradition in social inequalities research and, in certain contexts, are often used as principal modes of understanding and classifying social position (Williams, 1996). However, race and ethnicity in social inequalities in health research are generally used to analyze the health of marginalized racial or ethnic minority groups, rather than to represent the entire social gradient (which they tend to do poorly when used alone or in contexts where other mechanisms more strongly influence social stratification).

Nevertheless, in certain contexts, race and skin color has shown to be a strong predictor of, and highly correlated with, SES, even representing “social status independent of education level” (Williams, 1996). Although using race to represent SES, or social position, offers the opportunity to methodologically consider relevant institutionalized mechanisms associated with racial discrimination that may be poorly represented by more traditional measures of SES (such as income and education), this method is also limited by issues of poorly representative datasets, unreliable measurement and misclassification, and even research results being used as a *justification* for the exploitation of racial minority groups (Williams, 1996). Some of these limitations, however, may be moderated by incorporating race into analyses using a range of other perspectives for classifying social position.

The third general approach to methodologically classifying social position, which has gained some support in recent years, is distinguished by the characteristics of place (Kawachi et al., 2002). These studies, often focused on distinctions between rural and urban settings or within-city neighborhoods, focus on classification systems based on geographic location using, for example, the classification of zip codes. This approach is an interesting one as it has the opportunity to include “socioeconomic characteristics of neighborhoods [that] could

affect health through features of the physical (“built”), social, or service environments via multiple pathways” (Braveman et al., 2005). However this approach is also a challenging one methodologically, limited by diverse understandings of conceptualization and operationalization of the effects of place (Macintyre et al., 2002).

Of importance for the field of research on social inequalities (in health) are the cultural traditions that influence the understanding of mechanisms that (re)produce inequality. The cultural history of different global regions has shaped this understanding, which is reflected in the systems of social classification that exist in regionally dominant methods of scientific analysis. While education and income are widely used across countries and regions, occupation tends to be a much more appreciated, and used, measure of social position in much of Europe (particularly western Europe), while race is much more commonly used in North America (i.e. USA) (Braveman et al., 2005, Williams, 1996, Lahelma, 2001).

Regardless of cultural or regional variation, a consensus has grown around the importance of choosing methods of classifying SES or social position that are tailored to the aims and design of the study, relying on representative and statistically strong datasets and using multiple measures of SES, when possible (Williams, 1996, Gagné and Ghenadenik, 2018, Braveman et al., 2005). Using theoretically relevant, justifiable measures that estimate the importance of both material and non-material resources separately and comparing them – as is done in Paper III using education and income – can have important implications for understanding the relative importance of these differing groups of resources in a particular context (Beckfield et al., 2013).

Education is a particularly relevant measure of social position when measuring social inequalities in relation to health technologies (although other variables, such as income, offer interesting insights and should not be overlooked). This is due to education’s ability to capture powerful non-material effects such as health and technology literacy. When analyzing diabetes technologies, for example, as we do in Paper III, these literacy levels are central for gaining access to, and effectively using, these technologies. In fact, education has been shown to be a strong predictor of diabetes control (Geyer et al., 2006). However, using education as a measure of inequality does nothing to explain the production of these inequalities. Understanding the mechanisms that fundamentally (re)produce these inequalities should be as much of a goal of inequalities and health research as illustrating the effects of these inequalities on health (Paper IV attempts to explicitly address some of these mechanisms).

In contrast, when measuring health, the field has generally favored mortality data, particularly in cross-country comparative research. This is not surprising as mortality data is, compared

to other health measures, widely available internationally and is a reliable cross-country measure (i.e. there is little cultural influence in measuring death). Mortality data, however, while a reliable measure of years of life, is limited in its ability to measure the quality of life years, or, in other words, to represent both objective and, in particular, subjective quality of life and health over the lifespan (Lahelma, 2001).

Largely as an attempt to capture the lived (i.e. subjective) experience of health and quality of life, self-reported health has also been a commonly used measure of health in social inequalities research – see for example Mackenbach et al. (2008) and Balaj et al. (2017). Although this measure is not always a reliable measure of objective health (i.e. disease prevalence or severity), it is both very valuable in comprehensively representing health in a general sense (many aspects of health are both subjective and not necessarily traditional measures of health – such as the importance of a strong and reliable social network for health) and has shown a strong association with mortality. These strengths have resulted in the World Health Organization officially recommending the use of this measure for comparative studies (Beckfield et al., 2013, Lahelma, 2001). Moreover, in part to overcome some of the limitations of mortality as a measure, but also as an attempt to capture the effects of inequalities on specific diseases, many studies have relied on using morbidity data. Morbidity data may, for example, measure the prevalence of specific diseases (rates of cancer or diabetes, for example) or their severity, stratified by SES – see for example, McNamara et al. (2017). Paper III includes this approach, measuring diabetes prevalence based on education and income as well as using HbA1c levels as a relevant health indicator for representing severity and level of control of the disease. Other research has looked at variations in the use of valuable health services, such as screening or specialist care, based on SES – see for example, Link et al. (1998), Chang and Lauderdale (2009) or Fjær et al. (2017). This type of research is particularly relevant for the research in this thesis, as the use of services, such as cancer screens, and the use of health technologies, such as the blood glucose measuring devices included in the analysis in Paper III or e-health technologies analyzed in Paper IV, are similar for the theoretical and methodological design of the scientific analysis of SES-based inequalities. In particular is the central idea that innovative technologies, much like innovative services, are used to improve the effects of diagnostic and treatment procedures and can be exploited to avoid disease or improve health. All of the above-mentioned measures are of relevance for future research in the field of health technologies and inequalities in health.

3.2.2 Class as a contextual factor

It is important to note that traditional methods of measuring social inequalities in health, described above, are notwithstanding limitations. These limitations warrant a discussion as

they have motivated the theoretical and methodological perspectives underpinning the work in this thesis.

Of central importance is the often uncritical use of common variables of SES (as discussed above) as interchangeable, catch-all proxies for measuring social position in health research (Braveman et al., 2005). The uncritical use of these measurements does little to address the possibility that mechanisms responsible for connecting one measure of SES to health (education, for example) may not be the same mechanisms responsible for connecting another measure of SES to health (income, for example). The implications of uncritically substituting or favoring one measure over another may result in misinterpreting or even misrepresenting the relationship under investigation (as discussed in the results of Paper II) (Braveman et al., 2005). Second, these common variables of SES, used alone or in combination, are questionable representations of social position or, particularly, social class. As social position is often dependent on complex combinations of valuable social capital (herein, social capital is not referred to in the typical Bourdieusian sense – see Bourdieu (1986) or chp. 2.3.2– but rather as a general term referring to valuable sources, or 'assets', of meaningful power and status in society), measuring social position using a single variable of SES, or even a combination of these variables, does not guarantee valid representation of the mechanisms that produce social position, particularly as the relative power of these mechanisms may vary contextually (Grusky, 2018, Braveman et al., 2005).

Therefore, the perspective in this thesis is one that understands social position as a product of mechanisms of power (re)distribution in society. It therefore attempts to take a more balanced, and critical, approach to understanding social inequalities than much of the dominant quantitative health inequalities research that habitually uses SES as an independent or confounding variable of analysis, often presuming its durable and inevitable existence, before focusing on how SES influences health (Øversveen et al., 2017). This perspective is one of dominant success in investigating and explaining the robustness of SES to illustrate inequalities in health outcomes, and therein has been used to ground the analytical approach taken in Paper III. This approach, however central to much of the advancements in social inequalities in health research, has increasingly been criticized for its inability to continue to generate valuable results for the field of social inequalities research and, instead, often trends towards reaffirming established findings. This perspective, unfortunately, has done little to address the underlying mechanisms that cause valuable resources, including power, to be unequally distributed in society (Gabe and Monaghan, 2013, Øversveen et al., 2017).

With some of these critiques in mind, the work in this thesis attempts to provide a greater understanding of how innovative technologies are (conceptually and empirically) linked to health and social inequality. In order to do this, social position must be understood as more than simply a measure of SES. Rather, social position must also be understood as the product of powerful class structures. These powerful class structures, in turn, can be understood as contributing to the (re)production of the conditions that result in health inequalities (in other words, the conditions that create “the gradient”). One benefits, therefore, from understanding the social hierarchies and social position often measured by SES in health inequalities research, as highly influenced by social class. Herein social class is typically understood in relation to an individual’s position in the labor market, a general result of the industrial revolution’s ability to redefine social position based on the ownership of capital. This basic understanding of social class, although heavily debated and more recently criticized as an increasingly outdated method of understanding social class in modern society, nevertheless offers valuable insight into the powerful structural mechanisms that stratify social position and produce inequality in a market economy where power remains closely tied to the ownership of capital (Grusky, 2018). Bourdieu’s perspectives have both reinforced and built upon this perspective, importantly suggesting that “it is in fact impossible to account for the structure and functioning of the social world unless one reintroduces capital,” but has emphasized that it is important to recognize capital in all its forms (which, for Bourdieu, are analogous to power) (Bourdieu, 1986). Understanding social position as a representation of accumulated capital (i.e. power), in all its forms, therefore suggests that social class can be understood as fundamentally representing the institutionalization of social status and position, a valuable recognition that differentiates this perspective from one based on an understanding that merely represents a statistical construction of inequality (Grusky, 2018). After all, as Scambler has emphasized, “it is class relations, in short, that lock people into their SEC [socioeconomic classification]” (Gabe and Monaghan, 2013).

Integrating a variable that represents social class into specific analytical models has not been a central focus of the methodological perspective in this thesis. One could, in fact, question the empirical value of traditional measures of social class if one is open to questioning whether the very existence of these traditional classes are merely scientific constructs, as Bourdieu has done (Grenfell, 2014). However, a perspective based on social class as a way of understanding power relations based on capital accumulation has grounded the understandings of social stratification in this thesis. This is particularly visible in the theoretical interpretation of results, such as in discussions of the symbolic value of health technologies in Papers II and III and discussions of empowerment in Paper IV. Perspectives rooted in social class inform an understanding that social status is a representation of capital

accumulation, that capital accumulation tends to group individuals in society (which is then reinforced by in-group behavior and interests), and that this stratification allows for the reproduction of privilege, advantage and between-group domination. The intent of applying this perspective is an attempt to not only illustrate the social conditions in which inequalities in health exist but also an attempt to openly investigate the potential of relevant underlying social mechanisms that contribute to the (re)production of relevant inequalities as they relate to technological innovation broadly throughout society.

3.2.3 The “toolbox perspective” or “methodological polytheism”

The toolbox perspective is rooted in the old adage, “*if the only tool you have is a hammer, everything looks like a nail,*” which is a social rendering of an official passage from Maslow and Wirth (1966). It refers to a cognitive bias that an individual is prone to overly rely on, or inappropriately adapt the use of, a familiar tool. In research, this may lead to applying particular methods of data collection and analysis to a single study or an entire project that are inappropriate for the aims or design of the research question. In the most severe cases, resulting in the misinterpretation of research results. However, regardless of the correct application of specific methods, the less severe consequence of the over-application of a single method is the limited scope of the potential explanatory power of the research results.

Often, scientific inquiry is concerned with drawing clear causal links between social phenomena. However, the mechanisms at play are much more dynamic, fluid and complex. In *Pierre Bourdieu, Key Concepts*, Michael Grenfell summarizes the Bourdieusian perspective as one that understands the world as something that is not just “more complicated than we think, but more complicated than we *can* think” (Grenfell, 2014). From this perspective clear causation in health inequalities research becomes somewhat of an illusion. Instead, although it is possible – through systematic methodological inquiry – to create order to this complexity, the messiness of the mechanisms involved allow only for the possibility to establish associations. As Øversveen et al. (2017) have eloquently highlighted, identifying the mechanisms that contribute to an explanation of these associations, requires trading “a priori notions about SES, health and causality” for views that, instead, “conceptualize [SES, health and causality] as fluid entities existing in a mutually influential relationship.” The idea here being that the complexity of the interactions of these mechanisms and their related associations contributes to non-linear relationships that, as they materialize, are difficult to distinguish as the sum of their parts. As a contribution to understanding this complexity, and in line with Bourdieu’s methodological perspectives, Øversveen et al. (2017) recommend an approach that includes the use of a broad set of methodological techniques to comprehensively address and explain social phenomena,

including those concerned with inequalities in health – a call echoing that which has been made by a number of researchers in the field (Braveman et al., 2011, Baum, 1995, Scambler, 2012, Freese and Lutfey, 2011). In plainer terms, the above discussion could be summarized by simply stating that broad methodological application is both a prerequisite for, and contributes to, broad understanding of the phenomenon or relationship in question.

The use of a multimethod approach to understanding broad social questions is often referred to as a *mixed methods* approach, justified as a way of providing comprehensive understanding of a particular research question and often used to compliment the strengths and weaknesses of both designs (Jupp, 2006, Punch, 2013). Although mixing methods from the quantitative and qualitative disciplines is not new, efforts to define and add structure to the mixing of these methods to a degree that allows for the creation of a specific methodology is something of the last half century. Regardless of increased popularity in recent decades, an agreed-upon definition of this methodological perspective proves to be elusive. However, if we assent to the definition of mixed methods presented by Johnson et al. (2007) below, the methodological perspective in this thesis begins to reflect a mixed methods approach.

“Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration.”

However, for many, traditional definitions of mixed methods research involve mixing methods *within* a single study (Jupp, 2006). As the definition above alludes to, mixed methods research may also use a multimethod approach *across* studies – sometimes referred to within the mixed methods field as “sequential mixed method design” (Jupp, 2006) or what may, more loosely, be understood as a commitment to a philosophy of science similar to Bourdieu’s “methodological polytheism” (Wacquant, 1998, Bourdieu, 2004).

Indeed, Bourdieu, though not thought of as a modern prophet of mixed methods as a methodological discipline, advocates continuously in his work for the use of multiple methodologies across disciplines in order to obtain the best possible data and analytical foundation for answering research questions and understanding the social space. Bourdieu, in fact, had very little respect for traditional scientific and academic boundaries between academic disciplines. Rather than a weakness, this disrespect was a central strength in the contribution of his work to such broad areas of the social

sciences. It has, in large part, contributed to the exhaustiveness of the explanatory power of his theories of society. He has himself stated that he was concerned with actively working to “reunify an artificially fragmented social science” and that this work led him to a scientific practice that became simultaneously “anti-everything” and “catch-all” (Bourdieu, 2004). As such, Bourdieu uses his approach to practical application of theory as a way of providing an understanding for his emphasis on methodological polytheism.

From a Bourdeusian perspective, the theorist is concerned with generating hypotheses while the researcher is concerned with empirical testing. However, both are interested in explaining the world as it is represented in reality. For Bourdieu, either of these perspectives alone are inadequate in fulfilling this interest and it is only in the synthesis of these two perspectives that one is able to fully represent and understand the complexity of the social and natural world we inhabit. Therefore, Bourdieu advocates for an empirical perspective grounded in the merging of theory and practice where one is continually developing a *theory of practice* while simultaneously a *practice of theory* (Grenfell, 2014). In practical terms, this Bourdeusian perspective advocates for using whatever method suits itself most effectively to observing and verifying a particular inquiry into the social space and repeatedly challenging obstinate assumptions with, and the results collected by, various research methods (Wacquant, 1998). In any case, Bourdieu tended to always begin with a focused intent to answer a particular question of interest, rather than a particular intent to merely build on new or previous theoretical interpretations.

In a similar fashion, this thesis has no intention of grounding itself in an established tradition of mixed methodology and the debates surrounding the discipline. Neither does the work in this thesis take an active position in aspiration to be at once ‘anti-everything’ and ‘catch-all.’ However, the philosophical position in this thesis is one that is neither concerned with confining itself to the artificial boundaries of traditional scientific disciplines. Instead, the work in this thesis is concerned with the explanatory power of its theoretical and empirical positions, contributing to a body of the health and social sciences that provides as much social truth as conceivably possible. In this sense, the philosophical position of practically doing science underpinning the work in this thesis is one that – unintentionally but favorably – shares much in common with Bourdieu’s approach to flexibly and freely applying a methodological polytheistic approach. The methodological intent of thesis is to provide rich data material, an integration of (interdisciplinary) theories, and the investigation of paradoxes and contradictions – incessant themes throughout Bourdieu’s work. This thesis therefore

relies on the methods that follow as a preliminary attempt to offer a comprehensive understanding of the influence of innovative technologies on social inequalities in health:

1. **Review methods**

Reviewing the literature is, as McQueen and Knussen (2002) affirm, “a fundamental part of any study.” Here, the review of current literature is seen as a way of contextualizing a particular research question or single study. However, the same principle can be said to be true not just for a single study but for an entire planned course, or field, of inquiry. Reviewing the literature is a way of generating a comprehensive overview of a particular topic of interest. It allows for identifying gaps in the literature and provides a foundation to build on the theoretical and empirical findings from these previous analyses. However, the systematization and standardization of reviewing entire fields of inquiry have themselves become a methodological discipline, leading to the publication of “review articles” (Armstrong et al., 2011). Particularly for a field of inquiry that is relatively new or has not previously been explicitly addressed in depth, systematically reviewing the literature can be an important first step in the development of relevant lines of theory development and empirical inquiry. Reviewing the literature in a systematic manner may be understood as a way of becoming intimately familiar with the particular relationship under investigation while simultaneously focusing the research questions and broadening the understanding from which these questions are generated. In relation to the Bourdeusian perspective discussed above, where “data are collected first, and only then is theory developed” (Grenfell, 2014) review methods – which are primarily designed to comprehensively collect and analyze large amounts of existing scientific findings (i.e. data) in a systematic fashion – may be understood as a necessary first step in the development of theoretical foundations that may then be tested (or understood more deeply) using various methodological models.

Although various literature review methods have been standardized, scoping review methods have gained popularity in recent years. In Paper II we use systematic scoping review methods to review the range, nature, and extent of current research activity exploring the influence of innovative health-related technologies on social inequalities in health. We focus specifically on a deeper understanding of the variables used to measure this connection and the pathways leading to the (re)production of inequalities. Pham et al. (2014) summarize the intent of this method,

stating that scoping reviews “are commonly undertaken to examine the extent, range, and nature of research activity in a topic area; determine the value and potential scope and cost of undertaking a full systematic review; summarize and disseminate research findings; and identify research gaps in the existing literature.” As an attempt to systematically establish a theoretical and epistemological foundation for the work in this thesis, the ability of the scoping review to comprehensively examine the topic of interest and identify potential gaps in the literature was particularly interesting and important. As a review method, scoping reviews are also well-suited to investigating and condensing large amounts of information concerning complex topics with broad and open interests, where a variety of methodological paradigms are employed in the reviewed material (Levac et al., 2010, Arksey and O'Malley, 2005). Unlike systematic reviews, the methodological quality of included studies in a scoping review are rarely systematically assessed (and, in fact, often difficult to assess due to their heterogeneity) however this also allows for broader inclusion of related studies and, as a result, more comprehensive coverage of the topic of interest (Pham et al., 2014). Furthermore, although various standardized procedures have been proposed for scoping reviews – see, for example, Arksey and O'Malley (2005) or Levac et al. (2010) – a single standard has yet to be established (Pham et al., 2014). Nevertheless, as with any study based on qualitative analytical processes of text-based material, assuring methodological quality in a scoping review is based largely on a dynamic, reflexive process, whereby previous research questions and subsequent results are constantly reassessed using the most current understandings of the results of the review. These processes often gain strength with the inclusion of multiple researchers that are able to independently, yet collectively, compare and confirm understandings of the results. Paper II's methodological design relies on, and is exemplified by, the methods outlined above.

2. Regression analysis (quantitative)

Quantitative (statistical) methods are often, but not categorically, used to test theories in the health and social sciences. These methods rely on variable-based analyses of numerical data and therefore the analyses are fundamentally dependent on the quantifiability of the variables under investigation. These kinds of analyses often offer an objective understanding of the phenomena under investigation and are generally heralded for their ability to support standardized and replicable comparisons of measurements (Fries, 2009, Punch, 2013). Due in large part to the size of the samples, results of quantitative analyses often also support stronger generalization of

findings. Although there are a great number of methods for statistically analyzing the relationships between unique variables, it is regression analyses that are often used in the health and social sciences to predict the strength of a broad range of detailed relationships between groups based on various quantities and types of these variables (Punch, 2013).

From a Bourdieusian perspective, it is “statistical analysis of population...data to map the social location of users” that is the second strand in a reflexive methodology. The goal of this second strand of analysis in a reflexive methodology is, as Fries (2009) highlights, to use statistical techniques “to investigate how macrostructural factors such as age, gender, social class, educational attainment, and ethnicity relate to the use of,” in this case, various health technologies (however in Fries example it is various categories of alternative medicine). This can be seen in the methods employed in Paper III, where the use of educational attainment and income, from a Bourdieusian perspective, represent macrostructural factors that pattern behavior (Fries, 2009).

In Paper III we use regression analyses to investigate patterns of adoption and diffusion of innovative health technologies by socioeconomic status (SES). Three comparable panels of survey data (1984, 1995, and 2006) from the HUNT study in Norway were used to investigate the use of old and new diabetes technologies across panels and over time, based on groups of various SES, and compare these patterns with relevant health outcomes. Pensionable income data was used to create high- and low-income groups based on average median yearly income. Furthermore, education data was used to create low (lower secondary schooling), medium (upper/post-secondary schooling) and high (university education) educational attainment groups based on the National Standard Classification of Education in Norway (NUS). Linear regression with post-estimation was used to calculate age-adjusted diabetes-related health outcomes with 95% confidence intervals (95% CI) for each cross-sectional survey based on SES and the use of various technologies. Logistic regression models, adjusted for age, gender and length of illness, were used to examine associations between SES and the use of innovative technologies. Odds ratios (OR) and 95% CI were calculated for each survey as well as for a cohort followed across panels 1 (1984) and 2 (1995). All analyses were performed using Stata/SE 15.1

Although relatively small sample sizes limited some analyses, the above analyses allowed for exploratory investigations into whether “macrostructural factors” had a significant influence on the adoption and diffusion of innovative health technologies and, in turn, relevant measures of health. The strength of using these methods, therefore, lies in their ability to offer insight into objective mechanisms that reproduce structural inequalities. However, these methods are insufficient for providing insight into subjective processes that (re)produce these mechanisms. For this, one must move beyond Bourdieu’s second strand of reflexive methodology and employ qualitative methods that often allow for a deeper level of contextualization.

3. Text analysis (qualitative)

Qualitative methods are often, but not categorically, used to contribute to the generation or development of theory. However, to an even larger degree than quantitative methods, qualitative methods are extremely diverse and should not be thought of as a single methodological paradigm (Punch, 2013). This diversity in methods is a result, in large part, of the diversity in relevant questions in the social space that can, and are, addressed in different ways and through different perspectives by researchers (Punch, 2013). Regardless of this diversity, what characterizes these methods is often a reliance on case-based analyses of non-numerical data, such as the coding of text, that are naturalistic and developed more inductively than are typically quantitative methods. Data sources often include interviews, observation and/or documents. How sources are deemed relevant and are then collected, used, analyzed and interpreted presents many significant challenges in qualitative research where scientific rigor and order are central to limiting the effects of these challenges and creating confidence in results (maybe more so than with quantitative methods, which generally have stricter, standard protocols). However, qualitative methods are often heralded for their ability to offer a rich understanding of complex social phenomena, with deep consideration of contextual factors and a flexibility that promotes relevant adaptability to a great number of situations and purposes (Punch, 2013). These methods are often used to investigate the lived experiences of individuals or to study the larger context in which the individual lived experience inhabits. In Paper IV, qualitative methods of text analysis are used to unpack larger socio-political constructions that create the conditions that (re)produce inequalities, focusing on the national level.

From a Bourdieusian reflexive sociological perspective the above distinctions are important. The qualitative study of formal texts in Paper IV is a study focused on

subjective creations of society (political documents), and these subjective creations in turn limit the actions of individuals, reproducing inequalities at the socio-political level (Fries, 2009). Focus on both the importance of formal language in texts and the social understanding of the political context is central to Bourdieu's sociology. For Bourdieu, language is a form of domination (Grenfell, 2014). In fact, many markedly influential sociologists, such as Marx, Durkheim and Weber, have worked primarily from documents and official text (Punch, 2013). Furthermore, as Bourdieu has so eloquently stated before, social science's contribution to politics is its very 'raison d'être' (or, reason to be) (Grenfell, 2014). Therefore, this aspect of a Bourdieusian perspective to investigation and analysis would seem to fit well with other critical perspectives of social inequality and power from the likes of Van Dijk (2008) and Wodak and Meyer (2009) that consider the analysis of political discourse as an effective method of investigating the ways through which official use of text (re)produce dominance and social hierarchies.

Discourse analysis is particularly relevant for analyzing these officially structured forms of domination and power as discourses permeate every aspect of social life, producing ideologies, reflecting the human experience, and framing "everything people do" (Punch, 2013). Furthermore, discourse is encompassing of not just what and how something is said or communicated but also makes reference to the author and intended audience while also indicating the authority and objective expressed in the communication. Discourse, in other words is not just representative of current dominant ideas but has always been a socially exploited means of domination, often of more powerful agents over less powerful agents. This is often apparent in the representation of who generally controls dominant discourses in society. Discourse and power are never far from one another in society (Punch, 2013, Van Dijk, 2008). The relevancy of discourse broadly across society is represented in discourse analysis' use as a method of academic investigation in a number of various fields and disciplines within the social sciences, including the health sciences. However, despite its pervasiveness, discourse analysis as an empirical method lacks an overarching theory and is, instead, often referred to as a field of research more so than a single methodological practice (Punch, 2013, McQueen and Knussen, 2002, Van Dijk, 2008). Within this field, one can find reference to a number of varying theoretical perspectives that ground the empirical approach to discourse analysis, one of which being a critical perspective focused heavily on how power, control and inequality are reproduced and legitimized through text and talk (Wodak and Meyer, 2009).

From a practical perspective, a distinct set of methodological criteria for critical discourse analyses are, in fact, typically resisted in the literature, instead preferring a flexible method of empirical inquiry that considers the diversity in which critical discourse analyses can be applied. Nonetheless a number of various structural recommendations have been presented (Wodak and Meyer, 2009, Van Dijk, 2008). As is common in qualitative approaches, collection of documents is a continuous process using various search strategies, rather than a distinctive a priori phase of the analysis. Documents, such as the political documents included in Paper IV, are analyzed using coding techniques focused on a number of themes of interest designed to reduce and organize the data. Memos or summaries as well as visualizations of parts of the material support analysis. The aggregation of these strategies into a systematic qualitative process allows for an information rich investigation of larger socio-political contexts.

Paper IV uses methods of critical discourse analysis to investigate national public health policy discourse with specific focus on innovative health technology and social inequalities – in a Norwegian context. The intent of the study is to examine relevant “conditions of the political...practice [that] impose themselves practically ‘behind the back of the subjects’” (Wodak and Meyer, 2009) and, therefore, act as a concealed method of control (or symbolic violence: see chp. 2.3). In this study, control is understood through the State’s ideological and principle agenda for the development and adoption of health technologies across society. By investigating official documents from the perspective of dominated groups (i.e. low social position/status) it is possible to investigate whether these documents (re)produce inequalities by way of institutionalizing the (re)distributing of power and resources throughout society in favor of dominant group(s) (Van Dijk, 2008).

4. Inductive vs deductive strategies

Methods in this thesis have been both inductive and deductive. As a methodological tool, an inductive approach is well-suited for generating theory while a deductive approach is well-suited for testing theory. Sometimes the mixing of inductive and deductive approaches can be seen at a local level (i.e. within a specific study), as with Papers II & IV, whereas at other times this can be seen at the general level (i.e. the entire project), as with the (mostly) deductive testing of theory seen in Paper III and the (mostly) inductive generation of theory seen in Paper IV. It is, however, important to note that the ‘inductiveness’ and ‘deductiveness’ of the research in this thesis lies on a sliding scale and that no one part of this thesis nor the entire thesis

itself is devoid of processes that are both inductive and deductive in nature. The importance of this perspective lies in its cyclical nature, allowing for the continuous development and testing of relevant theoretical frameworks (not dissimilar to *grounded theory*). The flexibility of this approach does not suggest a lower level of systematization or rigor but instead the ability to continually (re)shape the research questions and relevant research methods to both integrate and address new information as it is received. This dynamic approach, grounded in a methodological polytheistic approach is, again, an attempt to develop an understanding of not only the ways in which technologies potentially (re)produce inequality but also the mechanisms that (re)produce this inequality. In other words, the flexible and dynamic, yet systematic and rigorous, use of multimethodology is an attempt to contribute to a multilevel (or 'holistic') theoretical and empirical understanding. This comprehensive understanding then allows for the development of a conceptual model revealing mechanisms centrally relevant to the relationship between innovative technologies and social inequalities in health, under current socio-political conditions.

3.3 ETHICS

Although human subjects were not used as a part of this research, statistical analyses have made use of databases which include pseudonymized personal information, including the Nord-Trøndelag Health Study (HUNT) and national registry data. In this case, study protocol was approved by the Regional committee for medical and health research ethics (reference 2017/603).

4 SUMMARY OF ARTICLES

4.1 PAPER I

Weiss, Daniel; Eikemo, Terje Andreas. (2017) [Technological innovations and the rise of social inequalities in health](#). *Scandinavian Journal of Public Health*. vol. 45 (7).

The aim of this paper was to position a research focus on the effects of technological innovations on health and inequalities into dominant academic discourses focused on the social determinants of health in social epidemiology and medical sociology. In addition, this paper was interested in identifying ways in which this topic may contribute to the foundations of a new research agenda. This discussion is based on the observation that during a time period characterized by increasing attention for growing social inequality in health and difficulties in explaining their apparent growth, there has been a stunning rate of innovative technological development, yet little research appears to have explored this connection. This paper therefore outlines a preliminary theoretical association between technological innovations and dominant inequalities in health research using the social determinants of health, fundamental cause theory and the diffusion of innovations theory. It offers both support and critique for these perspectives in association with a sociological and epidemiological approach to investigating technological innovations in relation to inequalities in health. It then provides perspectives that can be used to build on theoretical and empirical models for investigating and explaining the connection between technological innovations and social inequalities in health before concluding with recommendations for a new research agenda, including suggestions for relevant areas of important, yet largely absent, scientific inquiry. Therefore, exploring these critical questions will allow researchers and practitioners to better understand the influence of technological innovations on health and inequality and contribute to improving the general understanding of social inequalities in health. These efforts, it is argued, are particularly important as a move towards technologized individuals and a personalization of medicine and health have the potential to shift focus away from the “causes of the causes” and towards individual factors such as genetic information and the individual use of personalized technologies.

4.2 PAPER II

Weiss, Daniel; Rydland, Håvard T.; Øversveen, Emil; Jensen, Magnus Rom; Solhaug, Solvor; Krokstad, Steinar. (2018) [Innovative technologies and social inequalities in health: A scoping review of the literature](#). *PLoS ONE*.vol. 13:e0195447 (4).

The aim of this study was to systematically review the range, nature, and extent of current research activity exploring the influence of innovative health-related technologies on social inequalities in health, with specific focus on a deeper understanding of the variables used to measure this connection and the pathways leading to the (re)production of inequalities. A review process was conducted, based on scoping review techniques, searching literature published from January 1, 1996 to November 25, 2016 using MEDLINE, Scopus, and ISI web of science. Search, sorting, and data extraction processes were conducted by a team of researchers and experts using a dynamic, reflexive examination process. Of 4139 studies collected from the search process, a total of 33 were included in the final analysis. Results of this study include the classification of technologies based on how these technologies are accessed and used by end users. In addition to the factors and mechanisms that influence unequal access to technologies, the results of this study highlight the importance of variations in use that importantly shape social inequalities in health. Additionally, focus on health care services technologies must be accompanied by investigating emerging technologies influencing healthy lifestyle, genomics, and personalized devices in health. Findings also suggest that choosing one measure of social position over another has important implications for the interpretation of research results. Furthermore, understanding the pathways through which various innovative health technologies reduce or (re)produce social inequalities in health is context dependent. In order to better understand social inequalities in health, these contextual variations draw attention to the need for critical distinctions between technologies based on how these various technologies are accessed and used. The results of this study provide a comprehensive starting point for future research to further investigate how innovative technologies may influence the unequal distribution of health as a human right.

4.3 PAPER III

Weiss, Daniel Albert; Sund, Erik; Freese, Jeremy; Krokstad, Steinar. (2020) The diffusion of innovative diabetes technologies as a fundamental cause of social inequalities in health. The Nord-Trøndelag Health Study, Norway. *Sociology of Health and Illness*.

This study investigates patterns of adoption and diffusion of innovative health technologies by socioeconomic status (SES) in order to assess the extent to which these technologies may be a fundamental cause of health-related inequalities. Quantitative analyses examined SES-based inequalities in the adoption and diffusion of diabetes technologies. Diabetes data from three panels of the Nord-Trøndelag Health Study (HUNT), Norway, were combined with income and education data. Cross-sectional and longitudinal regression analyses were used to examine relevant inequalities. Cross-sectional analyses suggest often present SES-based gradients in the adoption of diabetes technologies, favouring high-SES groups. Statistically significant differences ($p \leq 0.05$) were most often present when technologies were new. In a cohort followed from 1984 to 1997, high SES individuals were more likely to adopt insulin injection technologies but, due to modest sample sizes, these inequalities were not statistically significant after adjusting for age, gender, and duration of illness. Moreover, compared to low SES individuals, high SES individuals are more active users of diabetes technologies. Results suggest that SES-based variations in access and use of innovative health technologies could act as a mechanism through which inequalities are reproduced. This study provides a discussion of mechanisms and a methodological foundation for further investigation.

4.4 PAPER IV

Weiss, Daniel Albert. (2019) Round hole, square peg: a discourse analysis of social inequalities and the political legitimization of health technology in Norway. *BMC Public Health*. vol. 19 (1).

This study aimed to investigate national public health policy discourse with specific focus on innovative health technology and social inequalities – in a Norwegian context. Although technological innovations in health have proven effective, their uncritical development and adoption leaves little room for understanding consequences that may undermine their aggregate social value. As research is increasingly understanding the impacts these technologies are having on social inequalities, political discourse is often a force promoting their development and adoption. The analysis in this study relies on a perspective grounded in critical discourse analysis (CDA), with inspiration from a discourse-historical approach (DHA) and political discourse analysis. Included in the analysis are central documents typically influential in the lawmaking procedure. Documents were coded and analyzed using Nvivo and supported by summary notes. The results and discussion focus on three major discourse strands: the “technologies discourse” (types of technologies), the “responsibility discourse” (who has responsibility for health and technology), and the “legitimization discourse” (the ways in which these technologies are legitimized). In conclusion, we find that despite an overt political imperative for reducing social inequalities in health, the Norwegian health technologies discourse gives little attention to the potential for these innovations to unintentionally (re)produce social inequalities. Instead, the discourse is characterized by neoliberal undertones that individualize and commercialize public health and promote a pro-innovation ideology.

5 DISCUSSION

5.1 SUMMARY OF FINDINGS

The overall aim of this thesis is to provide a greater understanding of how innovative technologies are, theoretically and empirically, linked to health and social inequality. The findings from this work have broad implications. By means of a multimethodological investigation, based on sociological and epidemiological perspectives, this thesis has engaged with theoretical, empirical and philosophical discussions relevant for understanding and explaining the socio-systemic mechanisms through which technological innovations, health and inequality are interconnected. Although the results of this investigation have produced as many questions as answers, these results have offered significant contributions to broadly understanding the position of technological innovations in society and the pathways connecting these innovations to population health and relevant social inequalities. The range of this work has, therefore, established a broad base from which to build future, targeted studies interested in exploring relevant topics. Papers I and II have offered an overview of relevant literature and a classification of technological innovations central to perspectives interested in understanding their role in the reproduction of health and inequality. Paper III tests an empirical model for analyzing adoption and diffusion patterns of health technologies from a social inequalities perspective. Paper IV provides insight into dominant political discourse and its relevancy for, often unintended, consequences of past, present and future technological innovations on public health and inequality. Furthermore, Papers II, III and IV provide evidence for a broad range of mechanisms, and potential pathways, illustrating how variations in access and use of innovative technologies (re)produces relevant inequalities. And, lastly, all papers provide relevant theoretical and philosophical discussions for further developing relevant scientific discovery. More specifically, the following findings are central contributions to these theoretical, empirical and philosophical explorations:

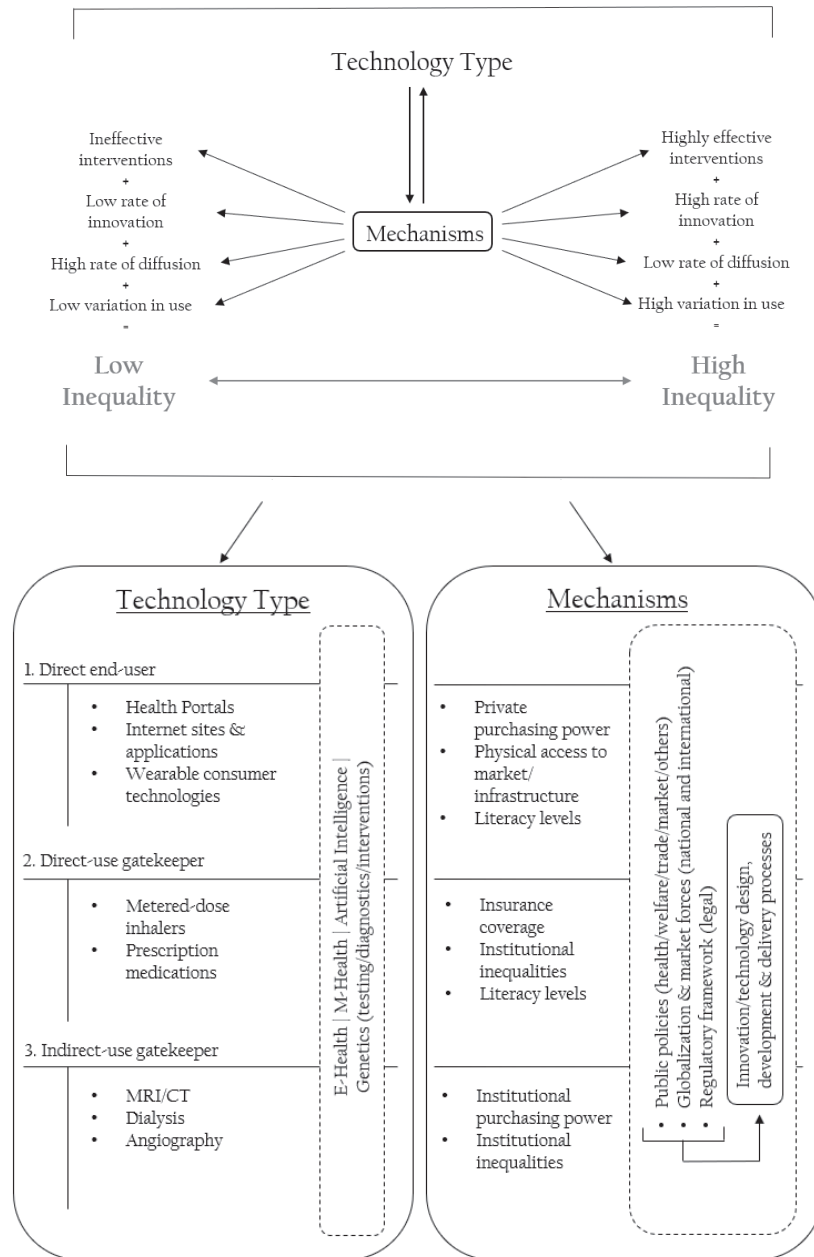
- Adoption patterns for health technologies show evidence for SES-based gradients, favoring high SES groups.
- SES-based gradients in the adoption of innovative technologies appear stronger than for old technologies.
- SES-based gradients in the adoption of health technologies appears strongest for technologies with slow (or low) rates of diffusion.
- High SES groups tend to be more active users of health technologies.

- Evidence suggesting that perspectives focused merely on SES-based inequalities in access and availability of technological innovations hides very real and potentially significant inequalities in SES-based patterns of use.
- Official political discourse focusing on technologies and health in Norway supports a pro-innovation and pro-technology bias. This discourse focuses in large part on legitimizing health technologies as resources for commercialization, economic efficiency and citizen empowerment, and appears to have little recognition for the possibility that technological innovations may reproduce existing inequalities.
- Official political discourse focusing on technologies and health in Norway prioritizes the adoption and diffusion of e-Health, ICT and welfare technologies, with interest growing for biotechnologies.
- Official political discourse focusing on technologies and health in Norway assigns responsibility for the adoption and diffusion of technologies in health in large part to local actors, such as municipalities and individuals, and increased public-private partnerships, while the State retains responsibility for setting national standards and coordinating national infrastructure.
- The development of a new method of classifying technologies in health based on mechanisms related to end-user access and use, with relevancy for associated SES-based inequalities.
- The preliminary development of a new, comprehensive model illustrating the mechanisms and pathways through which technological innovations in health may either (re)produce or reduce relevant social inequalities across society.

5.2 HEAL-TECH: THE PRESENTATION OF A CONCEPTUAL MODEL

Krieger (2008) has argued that conceptual models “are crucial for theorizing, depicting and explaining population distributions of health inequalities.” The findings from this thesis have allowed for the development of such a model, presented in figure 5 (below). This model forms a preliminary, yet comprehensive, foundation for further theoretical investigation, empirical testing, and general understand of the socially reproduced interconnectivity between technological innovations, health, and inequalities.

Figure 5: 'HEAL-Tech' – a conceptual model for understanding how technological innovations in health influence inequalities.



The HEAL-Tech model (figure 5) presents a pathway-dependent inequalities spectrum as well as a collection of mechanisms reinforcing or (re)producing 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 single, or set of, 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.

The importance of the effectiveness of a technology dependent intervention lies in its ability to determine relative advantage. Empirical tests of the FCT have 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, for example) has, therefore, little effect on inequalities (see Paper II, for example). 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 (see Rogers (2003) and results from Paper III).

The rate of relevant innovation 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 (see rates of diffusion below), 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 (i.e. 'hysteresis': see more on Bourdieu in Grenfell (2014) and chp 2.3.2) resulting from high rates of innovation, where new positions of power or advantage are continually created. A high rate of innovation again 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 (above), slow (or low) rates of diffusion allow relative advantage to be held for longer periods of time and, therefore, promote the (re)production of inequalities (see Rogers (2003), for example, as well as chps. 2.1.2, 2.3.1 and results from Paper III). 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 (for more on this see chp 2.1 and Papers II and III). 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 socio-politically constructed imbalances in status-related advantage (for more on between-group domination and symbolic violence see chp 2.3.2 and more on Bourdieu in Grenfell (2014) for details).

Some have suggested that the complexity of innovative technologies (or their interventions) is a significant factor determining the (re)production of inequalities (see Goldman and Lakdawalla (2005) for example). The argument is 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. Simple technologies, on the other hand, 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 innovation (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 (in health, for example). 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 figure 5 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. Here, we return to the categorization of technologies from Paper II, illustrated in figure 1 of this thesis (see chp. 2.1.1). This model divides health technologies 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 (private purchasing power, for example). An indirect-use gatekeeper technology (such as an MRI machine), in contrast, would influence, and be influenced by, mechanisms farther from the end-user (institutional purchasing power, for example) and closer to the institutions through which end-users typically access and use these technologies (see figure 5 for more).

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 offer an interesting example, as further illustrated in Paper III. 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 health care institutions – see, for example, institutional agency in chps. 2.2.2 and 2.3.2) 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 (see chp 3.2.1 and, again, Lutfey and Freese (2005) and Paper III).

Interestingly, the intermediary mechanisms in the HEAL-Tech model in figure 5 are a reflection of Bourdieu's forms of capital (see chp. 2.3.2). 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' grounded in the integration of FCT and Bourdieu's theories (see chp. 2.3.2 for more details).

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) (see the CSDH model), and the discussion in Paper IV. 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 markets¹⁸. 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,

¹⁸Antibiotics are a good example. These medications can have enormously powerful effects on the potential for delivering equal and effective public health services but their necessary development is to a large degree poorly prioritized by pharmaceutical companies due to relevant market forces and public health policies that make the innovative development of these medications financially unsustainable.

determines the collective composition of the environmental characteristics that directly influence the strength of existing inequalities.

5.3 IMPLICATIONS AND CONCLUSIONS

The results of the theoretical and empirical work in this thesis suggest that the powerful effects of technological innovations in health on mechanisms that significantly affect social inequalities requires the strategic and deliberate moderation of many of these mechanisms to avoid or reduce inequalities. The consequences of not doing so are significant, with far-reaching social implications.

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 Paper IV), these technologies have traditionally been, and in large part still are, available to individuals on the private market (i.e. 'direct end-user' technologies). 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, as the results from Paper IV illustrate, State governments are currently responsible for actively promoting and purchasing these technologies in many forms.

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, as shown in Paper IV), expanding the 'medical gaze' to a point in which individuals are increasingly and continually either monitoring themselves or being monitored by others (Lupton, 2013, Lupton, 2015, Lupton, 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 (increased medicalization can also lead to the social and medical acceptance of previously unaccepted 'conditions', for example), 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 'unhealth' 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, in his thesis on 'systems medicine', 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 – presented in the introduction of this thesis and highlighted in Paper IV – only add 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 (see Paper IV and Sveiby et al. (2012) for more). Both public and private attention is 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, leads 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 (see chp. 1.3). 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 positive effects. 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 have limited influence. In Paper IV, similar discussions 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." 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. high SES individuals) are increasingly being forced upon late adopters and laggards (i.e. 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, is 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 increased attention on the social determinants of health and inequalities (see chp. 2.2), 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, for example, Gabe and Monaghan (2013), Lupton (2015) and Paper IV). A shift in this direction is not without precedent, as a similar development in the field of epidemiology in the early years of the 20th century proceeded scientific discoveries and developments in the field of germ theory (as outlined in chp. 2.2.1). 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 socio-political contexts. This neo-liberalization of public health discourses on the back of technological innovations in health is already occurring, as illustrated in Paper IV.

Paradoxically, however, the predominantly positive representation of these technologies in dominant discourse relies strongly, again illustrated in Paper IV, 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 production processes and political discourses. The 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 is the embodiment of innovation-inspired symbolic violence and class-based dominance. Based on the broad implications of the results and discussions of the work in this thesis, it seems society would be wise to be wary of the unintended consequences of technological innovations in health on the distribution of power and capital and the (re)production of social inequalities.

The work in this thesis has the potential to contribute to a more thoughtful and effective understanding of the persistence of social inequalities in health across modern welfare state regimes. It may, in fact, offer insight into explaining, and possibly reducing, the unexpectedly high level of inequalities in health in the Nordic countries (i.e. the 'paradox'). Although some results are mixed, relevant research suggests that wealthy countries, such as Norway and other Nordic States, 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, for example, Andreassen et al. (2018) and the results in Paper III). Therefore, so long as these inequalities persist, SES-based variations in technology use, and consequently the level of received benefits, is 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 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 technologies are influenced directly (by private purchasing power, for example) while type 2 and 3 technologies are often influenced indirectly (by way of some form of gatekeeper). 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, for example, in Paper III). 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 (see, for example, Paper IV). 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 developed from the findings in this thesis as a conceptual foundation, there is reason to speculate that generous welfare States such as Norway, who are actively promoting effective innovation, have the economic and political means to stimulate the adoption of innovations at the national level, and 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, based on the findings from this thesis, *it is possible that developments in and around technological innovations in health in Norway (and possibly other Nordic states) are responsible for explaining much of the 'Nordic Paradox'*. These associations must be addressed specifically by future research. The Norwegian case presented here 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.

Until then, this thesis provides important conclusions. First, technological innovations have the potential to improve public health. Second, technological innovations in health do not benefit all social groups equally. These innovations may 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, therefore, have the power to both increase or decrease inequalities. The direction and magnitude of this relationship (i.e. relevant pathways) is shaped by a number of mechanisms at various levels of the social spectrum, which are dependent on important technological and socio-political 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. Therefore, 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 relevant 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. The findings from this thesis suggest that further development and investigation into these, and similar, concerns are likely to support similar conclusions.

Moreover, the philosophical, theoretical and epidemiological findings in this thesis have the potential to make a number of concrete contributions to future developments in both research and practice. First, they contribute to a long-standing debate regarding the neutrality of technology in society. These contributions defend an understanding of technology as value-laden and therefore non-neutral, particularly concerning effects related to social inequalities. By investigating technology in relation to health, this work investigates a field of social space that is invariably ingrained in the fundamentals of daily life and which is both influential for, and influenced by, mechanisms determining social position. Second, and maybe more importantly, the work in this thesis builds on previous theoretical and empirical findings, contributing a more comprehensive overview of the mechanisms through which innovative technology either increases or decreases social inequalities. This is done by further developing findings from the diffusion of innovations theory (picking up where much of Rogers' references to innovation's effect on inequalities left off) and integrating these findings

with important contributions from the FCT and elements of Bourdieu's theories of capital. A comprehensive attempt to aggregate and model the complete representation of mechanisms involved in the relationship between innovative technologies, health and social inequalities has yet to be either conceptualized or realized. Neither has there been adequate empirical investigation of the relative power of these mechanisms in influencing this relationship. This contribution may, in fact, be this thesis' most important to the health and social sciences (where purpose does not lie in uncovering absolute truths – which there are, in any case, likely very few of – but to provide an understanding of the circumstances in which *certain* truths either do, or do not, express themselves). These contributions, although significant, are a theoretical and empirical starting point. This starting point not only builds a scientific foundation for further development of these, and relevant, hypotheses and models for scientific inquiry. It is also a call to arms for a more conscious and aware engagement with the development and adoption of technological innovation, its position in society, and its potential consequences when left to its natural course within the current socio-political paradigm. This engagement is particularly pressing for concerns regarding public health and (often growing) social inequalities, particularly in relation to the development of modern social welfare regimes. Engaging with technological innovation in this way is a prerequisite to challenging, and transforming, current assumptions and guaranteeing equal access to health as a basic human right across social strata.

6 AFTERWORD

The ways in which technological innovations influence health and inequalities across society are broad and significant. The discussion that follows is an acknowledgement of several concerns that are not a product of theoretical or empirical findings from this thesis but, instead, of a broad range of overlapping scientific and scholarly debates. These concerns are likely to be important areas of social significance in the coming years and decades, and the fields of research and practice will likely be required to address them to a much larger degree than they currently are. Not only can these efforts possibly expand and improve the work in this thesis, contributing to a more complete picture of its overall aims and objectives, but, hopefully, the work in this thesis can also provide a relevant foundation for further scientific examination of these important issues.

Although throughout my work I was struck by the idea that innovations in health technologies, particularly the emerging technologies that for empirical reasons were difficult to investigate, had the potential of increasingly sorting groups of individuals throughout society into a new form of (*technological?*) class, it was Yuval Noah Harari that first gave these thoughts a structural terminology that I felt fit. In his book *Homo Deus*, Harari (2016) mentions the future formation of ‘biological classes.’ The idea he presents is that the future of health technologies, particularly bio and nanotechnologies, have the potential of so changing the human species that the kinds of benefits that early adopters and high SES individuals will be able to accrue will no longer be economic or symbolic but physiological. These technologies will, in fact, have the possibility of creating a ‘super race’ that is physiologically and biologically superior to the rest (Harari is not alone in thinking this, as genomics researchers such as Paul Knoepfler at UC Davis have shared similar ‘projections’ of the future). Of course, the implications for inequalities are enormous. As Harari (2016) puts it, “twentieth-century medicine aimed to heal the sick. Twenty-first-century medicine is increasingly aiming to upgrade the healthy. Healing the sick was an egalitarian project [but]...upgrading the healthy is an elitist project...” Furthermore, Harari highlights, “the cost of DNA testing is likely to go down with time, but expensive new procedures are constantly being pioneered. So, while old treatments will gradually come within reach of the masses, the elites will always remain a couple of steps ahead...if some form of upgrade becomes so cheap and common that everyone enjoys it, it will simply be considered the new baseline, which the next generation of treatments will strive to surpass.” In fact, one could conclude that much of the research in this thesis, in fact, supports Harari’s conclusions. Somewhat surprisingly, Harari further speculates that “by 2070 the poor could very well enjoy much better healthcare than today, but the gap separating them from the rich will nevertheless be

much greater,” seemingly echoing the conclusions of this thesis. Although this position may seem all together unrealistic or far-fetched, one must only see how far technological innovations have come in the last half a century to imagine where they might be in the next half a century. Based on increasing rates of innovation and the current state of emerging technologies in health, we are already seeing examples of the complete genetic elimination of particular traits or diseases, the biotechnological replacement of ‘faulty’ or sick parts of the human body, and the development of smart-home technology that can provide better care than some of society’s most sophisticated healthcare institutions. Barring a significant change in direction (which seems unlikely as even State governments seems to be heavily promoting the current technological paradigm), modern technological development will simply be a progressive step towards a global society mirroring Harari’s predictions. This society would be dominated by biological, rather than traditional ‘social’ classes, where humanity will once again have the 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 is important to remember that the potential for this society is simply the result of current and future technological class divisions, which is nothing more than a product of an uninformed or indifferent attitude towards current and future directions in the development and adoption of technologies for health.

Other concerns, however, are more immediate. Some of which we are already witnessing and other which we are already being forced to address. For one, as we move into current and future scenarios increasingly dominated by the rising value placed on information (references are increasingly made to the ‘information society’) and (‘big’) data, the, often sensitive, personal health data of individuals is becoming increasingly coveted by both public and private actors. As a result, health-related information is being collected at a frenzied pace by actors across society, from local municipal authorities to State governments and multinational NGO’s and from small start-up health services firms to large multinational corporations such as Google and Facebook. For public actors, these datasets promise increased surveillance and monitoring capabilities and the opportunity to more precisely target public services and potentially reduce costs (not to mention dominate international markets where health and technology are becoming increasingly profitable). Along these lines, private companies have understood the value in commodifying an individual’s health information, which can be used to more precisely and effectively develop and target marketable consumer products or control consumer behavior. These developments in and of themselves have significant moral and ethical implications (for example, who has the right to

collect this information, what information can be collected in a legally acceptable way, how can this information be used, and to what degree are these actors responsible for informing the individuals that are 'providing' them data?). These implications are particularly significant when private for-profit actors are not held to the same standards of information security and accountability as many public actors, increasing their relative advantage over public actors in an age where information and data is becoming a powerful tool to buy, sell, own and trade capital.

However, from an inequalities standpoint there are ethical, moral and practical concerns that are equally as significant but much less discussed in general discourse. These concerns center around issues of representation. These large datasets are consistently and reliably over-representing relatively high SES groups of individuals. One must only investigate the demographic representation of private genetic testing services, such as 23andMe or Ancestry.com, to see that these services are generally used by relatively affluent, white individuals of European descent. This is likely not a coincidence, as these technologies and services are generally developed by a similar demographic, harking back to earlier discussions in this thesis around the relevance of habitus, symbolic violence and the diffusion of innovations. Unequal representation in these datasets is exacerbated by the fact that these datasets are often used actively by organizations to design and market new technologies and to shape the behaviors of entire consumer groups (the information in these datasets is often more profitable than the products that are sold to collect this data). The results can already be seen in the development of a number of health technologies for diagnostics, treatment, prevention and promotion. This includes, for example, personal genetic technologies and prescription medications. Pharmaceuticals are being modelled and tested on the data found in these large datasets, often resulting in medications that are more effective for, and designed to combat illnesses that are more prevalent in, affluent white populations. Some may say that this trend is only natural, as these technologies are often in early phases of adoption, and that these datasets will become increasingly representative as diffusion rates increase. This may be so, however these technologies are sure to be replaced by newer technologies, where low-SES individuals will again be underrepresented and increasingly isolated from the benefits of technological 'progress'.

Furthermore, the consequences of technological-innovation-driven social inequalities is also being felt in labor markets, likely, on current political trajectories, only to get worse before it gets any better. The issue here centers around the technological replacement of manual labor. These developments are already apparent in industries characterized by part-time, low-skilled labor, such as manufacturing and distribution. However, similar trends are increasingly apparent in industries of full-time, high-skilled labor, such as courtrooms (lawyers

and judges) and healthcare institutions (doctors and other health personnel, particularly those involved in diagnostics). The replacement of manual labor with machines is of course not inherently negative. Machines and technologies are, for example, much less likely to need rest (increasing efficiency), more effective at consistently and reliably generating desirable outcomes in a number of situations, spare human beings from monotonous and sometimes dangerous work (that is, of note, often done by less affluent groups in society), and free up human beings for other purposes (including *not* working). In fact, technologies have been replacing manual labor for as long as they have been around, in many cases benefitting society (however have generally brought with them a collection of unintended consequences, which society has been required to deal with). There is, of course, no reason to believe that technologies cannot continue to replace human tasks to the benefit of society as a whole, where individuals and social structures do not suffer from increased technological innovation but, in fact, are freed by it. However, this is a vision that lies in the practical application of a social, political and economic system that requires a complete upending of much of the current paradigm, something not likely to occur for, at best, many years or decades. In the meantime, we will be required to face the consequences of increased automation and the technological replacement of many sectors of the labor market. Under the current system, as we are already witnessing, this will create a full spectrum of winners and losers. Currently, and likely to continue in the future, the losers are often groups of low SES, who have a more difficult time (at no fault of their own) adapting to these disruptions.

The unequal distribution of the consequences of these technological innovations are, again, apparent. For many in the globalized market system, losing employment also means losing health (in the form of lost insurance coverage or a general reduction in financial wealth, for example). With the (exorbitant) rising costs of health care, the loss of insurance or income could be, quite literally, life-threatening for many. Although this may not be true in countries with universal health care systems (of which there are many), the loss of a job is at the very least a temporary loss in income and employment status, and the (very real) potential for a forced career change (and possibly the loss of employer-paid private insurance coverage). All of these disruptions can have significantly damaging effects on aggregate levels of individual capital and the resources that, both intentionally and unintentionally, secure an individual's health. The likelihood that these consequences will be unequally borne by lower SES groups is high. Regardless of whether or not these developments in technological innovations also move in to replace, in some cases, the jobs of affluent individuals (like doctors, lawyers, etc.), it is individuals with lower levels of aggregate capital (economic, social, cultural, and political) that will be least likely to successfully overcome disruptions

resulting from the technological replacement of entire sectors of the labor market (in fact, high SES individuals may even be able to *take advantage* of these disruptions).

These consequences deserve more attention, from relevant communities in both research and practice. Currently, these consequences seem to be often unrecognized, brushed off as unrealistic (a very dangerous and misguided position, often argued by technologists, since we know that these consequences are fully realistic, particularly in a scenario where they are given little or no attention), or completely ignored. Seeing profits and economic growth as a singularly important factor in prompting these technologies, and misrecognizing purely economic gains as *collective* 'progress', completely ignores the very real experiences of individuals who are often in social positions that afford less influence over dominant social and political discourse. The very real results of which we may be witnessing as the progressive polarization of society and the growth of nationalist (i.e. anti-globalization) and populist movements across powerful and often cosmopolitan parts of the world (USA, Brazil, U.K., Poland, Italy, and even the traditionally liberal social-democratic countries in Scandinavia).

However, there is one factor that will have a significant impact on the consequences of an increasingly technological future, particularly in sectors of health and care. In many cases it is the elephant in the room, regardless of the topic of discussion – and therefore requires attention and integration into all policies and future priorities. It also has the potential to both undermine technological 'progress' and amplify social inequalities. It is climate change. The afterword of a doctoral thesis, particularly one in a field unrelated to climate science, is no place to offer in depth discussions of the implications of climate change. However, it is interesting and important to note its significance with regard to discussions relevant for this thesis. The irony, one could say, is that society's past technological innovations have, to a significant degree, created the very changes in climate that threaten to undermine the importance of technological innovations in the future (not to mention the entirety of humanity and life on earth). Continued resource availability, the efficiency and health of the human labor force, and the social, political and economic stability necessary to support the current rate of technological innovation cannot be guaranteed in a future where the effects of climate change are left largely unaddressed. In fact, we are already aware that society will suffer (and in some parts of the world already are suffering) a great deal of consequences associated with these issues, leaving communities strapped for resources where innovation is necessary but where technological innovation (at least increasingly sophisticated technological innovation) becomes almost impossible. Of course, technological innovation is often promised as a source of salvation from these climate-related concerns (i.e. "*just wait a few more years and all our problems will be solved by a new technology*"). The reality,

however, is that society already possesses the technologies necessary to mitigate many climate issues. However, current political and economic paradigms often undermine efforts to effectively implement and use these technologies on a large enough scale, or create barriers to using our political, rather than technological, tools to remedy the situation. In any of the current climate projections, the consequences of any one of our technological visions for the future are likely to increase the effects of social inequalities (including those discussed in this thesis), at least in the near term. In a scenario characterized by any level of increased resource scarcity, valuable resources – that are highly influential in creating and maintaining good health, and which may only become more influential as our traditional institutions are forced to confront resource scarcity – will likely be further concentrated in the hands of high-status individuals. These challenges are real, and we will be increasingly forced, regardless of our political or social position, to confront them. However, regardless of whether these challenges concern climate change, health or social inequalities, they are simply some of the many challenges threatening the social stability of our global future. The current overwhelming suite of social challenges presents a very real socio-political ‘triage problem’, where society is, and will be increasingly, required to assign degrees of urgency to the great social challenges that we are forced to confront. Regardless of how we go about the difficult job of triaging these challenges, however, it is obvious that the longer we wait, the more disruptive will be the effects, with ever more dire consequences for social inequalities and health, particularly for society’s most disadvantaged.

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DEBATE ARTICLE

SIR MICHAEL MARMOT SPECIAL ISSUE

Technological innovations and the rise of social inequalities in health

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Abstract

Social inequalities in health have been categorised as a human-rights issue that requires action. Unfortunately, these inequalities are on the rise in many countries, including welfare states. Various theories have been offered to explain the persistence (and rise) of these inequalities over time, including the social determinants of health and fundamental cause theory. Interestingly, the rise of modern social inequalities in health has come at a time of great technological innovation. This article addresses whether these technological innovations are significantly influencing the persistence of modern social inequalities in health. A theoretical argument is offered for this potential connection and is discussed alongside the typical social determinants of health perspective and the increasingly popular fundamental cause perspective. This is followed by a proposed research agenda for further investigation of the potential role that technological innovations may play in influencing social inequalities in health.

Key Words: Social, inequalities, health, social determinants, diffusion of innovations, fundamental cause, technology, medical sociology, marmot

Technological innovations: ‘All about potential’?

The number one benefit of technology is that it empowers people to do what they want to do. It lets people be creative. It lets people be productive. It lets people learn things they didn't think they could learn before, and so in a sense it is all about potential.

Steve Ballmer, CEO, Microsoft, 2010–2014

Potential is the expression of possibility. It is an idea that often contains much hope and anticipation. But hope and anticipation for what? And for whom?

Although some label the idea of a society with a fairer distribution of power, money and resources – where good health and quality of life are more evenly experienced – as a fantasy [1] consisting of social, political or economic impossibilities, others believe this ‘fantasy land’ to be a realistic possibility. The

unfortunate reality is that a growing body of research illustrates that social inequalities in health are apparent and in many cases increasing at an alarming rate, even in high-income countries [2–4]. Interestingly, these inequalities do not just exist between rich and poor, but their existence is apparent within and between every social stratum. Many years of work on what has subsequently been deemed the social gradient – the understanding that regardless of where an individual finds themselves on the social hierarchy, their health will generally be both better than those below them and worse than those above them – has established a foundation for further interest in research and practice focused on social inequalities in health [5,6]. These inequalities have been categorised as a human-rights issue that evokes both moral and ethical considerations

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and therefore requires action [7–9]. Various theories have been presented to explain these inequalities, including cultural capital, life-course exposure to biological and social factors, exposure to psychosocial stress, the accumulation of both material and non-material resources, social selection, personal characteristics, innovation (not necessarily technological) and the inevitable presence of relative inequalities due to a mathematical artefact [3]. Many of these theories rely, at least in part, on the unfair distribution, accumulation, access and/or use of various resources [10]. Remarkably, as far back as the 1970s, research began to connect the theory of the diffusion of innovations (then relatively young) to an increase in social inequalities. This connection eventually resulted in the theory's forefather, Dr. Everett Rogers, to decree that 'the consequences of the diffusion of innovation usually widen the socioeconomic gap' [11]. Given the stunning rate of innovative technological development during the very same time period that the social gradient in health provided a deeper understanding of social inequalities in health, it seems surprising that more attention has not been given to the potential role technological innovations in health have played on social inequalities in health.

Some may wonder whether technological innovations are the symbol of progress – a resource that has saved so many lives and improved the health and well-being of so many. A resource it may be, but is it one designed to deliver us unquestionably from the burdens of social challenges including, for example, inequalities in health? Technological innovations may have great potential to improve quality of life for many, but is it safe to assume that a focus on technological innovation will contribute to society's greatest health improvements? May focusing on reducing health inequalities, and the potential that technological innovations may contribute in this endeavour, have greater impact on improving health for all? To answer this requires contextualisation. First, one must understand technological innovations from the perspective of health disparities.

Health: A distribution of resources perspective

Understanding social inequalities in health and the contexts and mechanisms through which these inequalities manifest themselves has been a challenge, likely a result of the necessity for understanding significant systemic complexity [3,12]. Understanding systemic complexity and the interactions between individuals, institutions and social, political and natural environments becomes particularly important when one accepts that health is created not in

health-care institutions (where disease and illness is treated) but in the everyday settings in which people learn, work, play and love [13]. Reducing social inequalities in health, some defend, is dependent on individual access to, knowledge of, and the ability to use the resources found in the everyday settings that create health [14]. These resources are everything from access to healthy food, leisure time activities and health-care services to income opportunities, knowledge and education and social networks. Complimentary perspectives often refer to these resources somewhat differently, some describing them as 'flexible resources' forming the 'fundamental causes' (i.e. fundamental cause theory) of health disparities, while others use them as a foundation for defining the Social Determinants of Health (SDoH) [15–17]. These perspectives are typically presented autonomously. However, both attempt to explain social inequalities in health by attempting to address the 'causes of the causes' by way of an access to resources perspective. Work by the Commission on the Social Determinants of Health at the World Health Organization has previously acknowledged that combatting social inequalities and improving health may benefit most from creating a sociopolitical environment with equal opportunity to access and use the resources (material, psychosocial and political) that create health [18]. However, understanding how unequal access to, knowledge of and use of particular resources in our society influence and potentially propagate social inequalities is important to reduce and manage health disparities. Phelan and Link (fundamental cause theory) have similarly declared that 'if we redistribute resources in the population ... inequalities in health should also decrease' [17]. However, although some of these resources may be designed to improve health and quality of life, unintended consequences may in fact widen social inequalities as a result of socially constructed exclusivity in individuals' lived experiences with a particular resource's ability to promote health, reduce risk-factors and accidents (prevention) or combat disease (treatment) [14,19,20].

Technological innovation and health (in)equality

Although technological innovations¹ are, without doubt, a resource that has become highly influential in modern society, improving health and quality of life and reducing all-cause mortality [21–23], an increased amount of research is establishing that innovations may in fact increase social inequalities [11,20]. As the theory of fundamental causes demonstrates, access to and use of these technological innovations are often

dependent on other flexible resources determined by an individual or group's socio-economic status (SES) [20]. These resources are used to access, adopt and effectively use technological innovations. Furthermore, Rogers' theory of diffusion of innovations illustrates that early adopters gain additional benefits simply from adopting innovations early – what are described as 'windfall benefits' [11]. These windfall benefits are often economic in nature, creating profits for early adopters of a new technology that are minimised as more people adopt. However, other windfall benefits may also be accrued simply by adopting early, allowing for the accumulation of benefits gained from an innovation over a greater period of time (also very dependent on the time taken for an innovation to diffuse). Therefore, those with greater prior resources (higher SES) gain earlier and easier access to new resources, increasing the amount of resources at their disposal and therefore increasing social inequalities. In this fashion, technological innovations provide a potential mechanism for sustaining social inequalities (through the continuous development of innovations), as well as simultaneously increasing social inequalities (through the accumulation of windfall benefits) [11]. Consequently, although technological innovations may improve the health of those with fewer resources, this advantage often occurs at a much slower and stunted rate compared to those with greater resources, creating a disparity where low SES groups are left behind. These conclusions, however, must not ignore research that suggests the possibility of technological innovations decreasing social inequalities in health, particularly when these innovations simplify access to technologies that benefit health outcomes [24]. Unfortunately, such studies often ignore variations in the use of these technologies based on SES that may be equally important as access. Nonetheless, regardless of their potential consequences, innovative technologies have traditionally been considered positive developments, with little discussion of their unintended consequences [11]. Although some of this is due to the difficulties and challenges associated with measuring complex social consequences, much of this is likely due to the research and development of new technologies conducted by organisations that profit from the sale and diffusion of new technologies or innovations [11].

This begs the question of how society reconciles its perplexing and often contradictory relationship with technology. What if the very representation of modern-day progress (technological innovation) is also slowly eating away at its foundation (comprehensive public health)? It is of course possible that this perspective is perhaps impracticable or even unnecessary. But is it not worth asking, and investigating whether

technological innovation is causing unintended, and potentially significant, negative side effects on social health and equality? If so, how do we proceed?

Factors versus mechanisms

Some researchers have proposed that the relatively common focus on individually available resources, addressed by, for example, fundamental cause theory, is limited in its scope. These researchers highlight that this perspective ignores the mechanisms that may be equally or potentially more influential, assuming that access to and use of individual resources is conscious and intentional [25,26]. These researchers suggest instead that systemic mechanisms drive the unequal distribution of social determinants of health independent of the condition of these determinants. In other words, merely improving the SDoH, for example, does not ensure their equal distribution. Understanding that education heavily influences an individual's social position, and therefore health, for example, does little to explain why certain social groups have continuously poorer access to educational opportunities, why these opportunities often benefit some groups less than others, why these disadvantages are typically passed on through generations and how educational institutions and agents within these institutions may be reinforcing these disadvantages. These are mechanisms that influence individuals but that individuals can seldom influence by deploying or using available resources. As Graham [15] so clearly demonstrates, although the SDoH may be important factors influencing health, these determinants may differ drastically from the determinants, or what Freese and Lutfey [25,26] refer to as mechanisms, that influence health *inequalities*. It is important to consider that these mechanisms may maintain or enhance social status through the combination of many small, pervasive advantages that influence decision-making processes of individuals, or their experience(s) with an institution and its agents, regardless of conscious or initial intent [25]. Many of the mechanisms that produce patterns of distribution, availability, use and effects of these resources are shaped by institutions that include, for example, hospitals, schools, employers and political and legal organisations. As Freese and Lutfey [25] demonstrate, 'access, utilisation, and adherence [of personal resources] are moot if one's SES potential for purposive health improvements is undermined by the action of the institution and its agents'. In other words, a perfect redistribution of the resources that create health does not mean a perfectly equal society. The way in which the use of these resources is influenced by the institutions that 'distribute' them has the potential to

challenge the equalling effect of their even distribution. This focus on institutions and mechanisms that produce and reproduce inequalities challenges the well-established social determinants perspective to dig deeper than the determinants themselves and uncover both that which produces their unequal distribution and that which produces their unequal outcomes. If society's proliferation of technological innovations as a resource influencing health reduces or (re)produces health disparities, then must it not be considered that the use and manipulation of this resource by social institutions produces persistent mechanisms that influence health disparities?

Institutions and innovation

Political institutions are one such example of a highly influential social institution. In many cases, they are responsible for the regulation of numerous sectors in society and therefore have the potential to influence mechanisms that have a powerful effect on both the diffusion of innovations and the development and persistence of social inequalities in health through, for example, tax and income structures, 'sponsorship' of ideas or technological innovations, environmental and human-rights regulations and the regulation of the private sector and free trade – what could also be seen as institutional activities that explain the distribution and variance of many of the social determinants of health across SES [2,25,27,28]. Political institutions, it may be argued, ultimately have responsibility for promoting and distributing health evenly throughout a society – rather than simply providing care or information. Therefore, understanding these political institutions' attitudes and perceptions of innovation and technology as a potential influencer of both health and inequalities in health is thus important to understand if the mechanisms created and influenced by political institutions are affecting the variance in social inequalities. It may be particularly interesting to examine whether a traditionally common *pro-innovation bias*² exists within these institutions and if supported technological innovations in turn sustain or possibly increase social inequalities in health [11]. This may be positive if these innovations have the ability to promote health or eradicate disease, particularly if their adoption is rapid enough to prohibit the development of inequalities or is primarily focused on improving the position of lower SES groups, such as government-implemented vaccine programs. However, if the adoption of these innovations comes at a (potentially unanticipated) cost to society, particularly for certain social groups, this *pro-innovation bias* may encourage inequalities,

such as with poorly regulated government support or implementation of expensive diagnostic machinery in hospitals [29]. Furthermore, it is not certain that the attitudes and perceptions of political institutions and their agents represent the attitudes, perceptions and challenges of the social groups these agents are responsible for representing. Therefore, it is possible that a gap exists between the mechanisms that political organisations create and influence and the variables that affect resource use at the individual level. Further investigation of the mechanisms that affect unequal distribution of resources at a systemic level, including how political institutions perceive technological innovations, will aid in providing a comprehensive understanding of how technological innovations affect social inequalities in health throughout society.

Setting a new research agenda

Empirical investigations exploring the unequal distribution and use of technological innovations on an individual's SES are far from numerous. Even fewer studies have addressed this issue from an institutional perspective. Studies that have furthermore explicitly combined the theory of diffusion of innovations and fundamental cause theory to investigate the role technological innovations play on social inequalities in health [28,30,31] seem to be extremely rare. Further research in this area is required in order to understand the multidimensional consequences of innovative technologies on health inequalities and to investigate whether technological innovations are an important factor influencing both the persistence and increase of social inequalities in health. This understanding must include:

- (1) A still non-existent overview of current and past research documenting technology's influence on social inequalities in health, including the establishment of important definitions related to technological innovations in health.
- (2) Further investigation into the magnitude to which health technology is an influencing factor of social inequalities in health.
- (3) How new health technologies (innovations) diffuse throughout the population.
- (4) What important mechanisms potentially influence these diffusion processes and potential differences leading to social inequalities.
- (5) What the role of various institutions is in creating and influencing these mechanisms.
- (6) How these institutions perceive technology and technological innovations' role in creating, sustaining, increasing or reducing social inequalities in health.

- (7) How these perceptions compare to the experiences of individual 'users' (i.e. the general public) at varying socio-economic levels.
- (8) What the sociopolitical implications are of these findings.

Exploring these critical questions with an open, multidisciplinary approach and a perspective rooted in social science and medicine will hopefully allow us as researchers and practitioners to understand more fully the extensive influence of technological innovations on health and the complicated dynamic that is social inequalities. These and similar investigations have the potential to expand the scientific community's understanding of social inequalities in health and stress the importance of social mechanisms that significantly influence the health of various social classes. These efforts are particularly important with regards to innovation and technology, as the move towards technologised individuals and a personalisation of medicine and health have the potential to shift focus away from the 'causes of the causes' and towards individual factors such as genetic information and the individual use of personalised technologies [32–34]. Left unaddressed, these developments would have the potential to undermine many years of research on the SDoH and the fundamental causes of social inequalities in health. As a result of these investigations, it will be possible not only to understand better whether technological innovations' potential may live up to the bold opening remarks by Steve Ballmer, but also will contribute to an understanding of who this valuable potential may benefit most. This endeavour will not come at the expense of influential, foundational research on fundamental causes and the SDoH but rather will build and expand on them.

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Notes

1. Here, we define technological innovations as 'ideas, practices, or objects perceived as new by an individual or other unit of adoption ... [resulting in a] design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome' [10]. Correspondingly, technologies often contain a hardware component, such as a physical tool or machine, and a software component, such as the knowledge that often accompanies the use of this hardware. In order for this technology in addition to be innovative, it must be perceived as new by its users. Examples in health include newly developed medications, diagnostic or treatment tools or machines, electronic or Internet-based applications and any wearable device that monitors health status or behaviour.
2. A pro-innovation bias supports the idea that innovations provide important benefits for users and therefore, the adoption of these innovation in their current form should be facilitated with the ultimate goal of 100% adoption by society.

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RESEARCH ARTICLE

Innovative technologies and social inequalities in health: A scoping review of the literature

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Abstract

The aim of this study was to systematically review the range, nature, and extent of current research activity exploring the influence of innovative health-related technologies on social inequalities in health, with specific focus on a deeper understanding of the variables used to measure this connection and the pathways leading to the (re)production of inequalities. A review process was conducted, based on scoping review techniques, searching literature published from January 1, 1996 to November 25, 2016 using MEDLINE, Scopus, and ISI web of science. Search, sorting, and data extraction processes were conducted by a team of researchers and experts using a dynamic, reflexive examination process. Of 4139 studies collected from the search process, a total of 33 were included in the final analysis. Results of this study include the classification of technologies based on how these technologies are accessed and used by end users. In addition to the factors and mechanisms that influence unequal access to technologies, the results of this study highlight the importance of variations in use that importantly shape social inequalities in health. Additionally, focus on health care services technologies must be accompanied by investigating emerging technologies influencing healthy lifestyle, genomics, and personalized devices in health. Findings also suggest that choosing one measure of social position over another has important implications for the interpretation of research results. Furthermore, understanding the pathways through which various innovative health technologies reduce or (re)produce social inequalities in health is context dependent. In order to better understand social inequalities in health, these contextual variations draw attention to the need for critical distinctions between technologies based on how these various technologies are accessed and used. The results of this study provide a comprehensive starting point for future research to further investigate how innovative technologies may influence the unequal distribution of health as a human right.

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Introduction

Despite expectations to the contrary, social inequalities in health appear to be increasing in many of the world's most developed countries during an era of rapid innovative technological development [1–3]. As the quantification of health in modern society intensifies and innovative health technologies become the cornerstone of this transition, the connection between technology and health is garnering increased attention [4–7]. Recent years have witnessed an era of intensified technology use in health care services [8] as well as developments in personalized medicine and the use of big data for health purposes. These advances have promoted a growing dependency on technology in society and the collection of advanced information, including that of the personal genome, which are then used to influence the decisions and behaviors of not just ordinary citizens but also health personnel, private companies, and large institutions [9–11]. These innovations are generally seen as positive developments, improving the diagnostics and treatment of disease as well as general public health, however their wider societal implications can be questioned [10, 12–14]. It appears likely that these technologies could be improving general public health but at the cost of increasing inequalities in health [13, 15].

Various publications have addressed the importance of further investigating the potential implications that the rapid development and increased prioritization of various technological innovations in health have on the health of society as a whole [3, 10–12, 16, 17]. Other studies have empirically investigated the production of inequalities in health due to the advent of innovative technologies [18–20]. These studies demonstrate that individuals of higher socioeconomic status (SES) are the first to adopt, and benefit most from, the introduction of innovative technologies in health, creating social inequalities in health where they were once very low or nonexistent, or in some cases even inverting these inequalities (where improved health outcomes have moved from lower SES groups to higher SES groups). This phenomenon is further illustrated by results demonstrating larger social inequalities in health among populations suffering from illnesses for which effective preventive or treatment techniques have been developed [21]. These studies provide a starting point for investigating additional mechanisms that may explain the (re)production of social inequalities in health [22, 23]. As the rate of innovative health technology intensifies, a better understanding of this perspective is becoming increasingly important.

Still missing from the literature is a broad foundation from which to further investigate and explain the connection between technological innovations and social inequalities in health. The following questions are still in need of clarification:

- How are *innovative health technologies* defined in a social inequalities context?
- What are the implications of using various measurements of social inequality?
- How do existing studies explain the potential relationship between *innovative* health technology and social inequalities in health?
- How may *innovative* health technologies reduce or (re)produce social inequalities in health?

The aim of this study, therefore, was to systematically review the range, nature, and extent of current research activity exploring the influence of innovative health technologies on social inequalities in health, with specific focus on a deeper understanding of the variables used to measure this connection and the pathways leading to its (re)production.

Methods

A systematic search process was conducted, based on scoping review techniques, [24, 25] for literature published from January 1, 1996 to November 25, 2016 using the following databases:

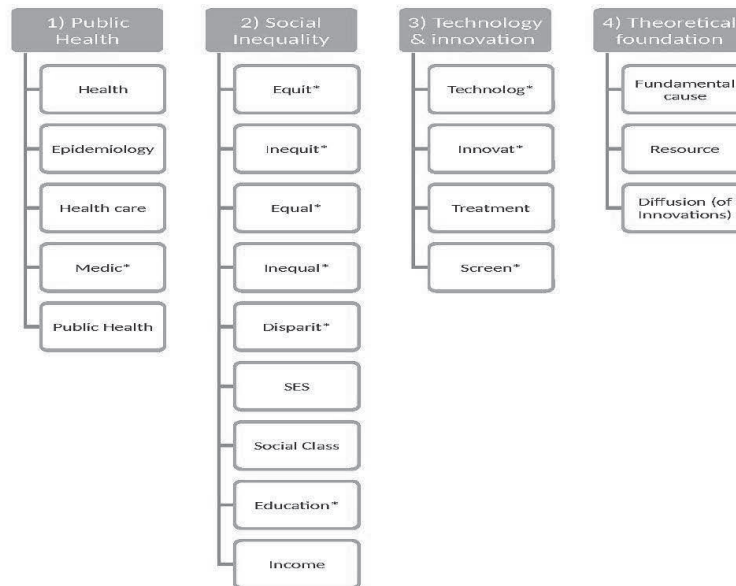


Fig 1. Search terms and their categorization into overarching themes.

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MEDLINE, Scopus, and ISI web of science. The search was updated on November 25, 2016. Scoping review methods were used for their ability to explore broad research questions and interpret large amounts of material from various forms of data and research, while providing an important first step in synthesizing a complex body of research that can be used to guide the direction of future research [26, 27].

Search terms were categorized into four categories (“public health,” “social inequality,” “technology and innovation,” “theoretical foundation”) in order to provide additional organization when combining terms during the search process (Fig 1). Only peer-reviewed studies based on original data analysis were included in this study, as interest was focused on collecting empirical analyses. A full overview of inclusion/exclusion criteria can be found in Table 1.

The initial search process was performed by two research librarians with expertise in the use of literature databases. Extensive testing of the search strings was performed before the search process. To reduce the number of irrelevant hits and increase accuracy of the searches, a proximity operator was used as well as custom search strings for each database. Rationale and search strings for each individual database can be found in Table 2.

The initial search resulted in a total of 4139 studies, after cleaning of the original data file. After sorting the dataset alphabetically by study title, the entire dataset was divided into four equal subsets. Each subset was then sorted independently by two individual researchers.

Table 1. Inclusion/Exclusion criteria.

Inclusion Criteria	Exclusion Criteria
English Language	Before 1996
Peer-reviewed original study or review, based on an original data analysis	Focus on health services or health care without specific focus on technology and inequalities
Addresses inequalities in health outcomes (also called health disparities, inequalities in health, health inequity, equity in health, etc.)	Innovations without a technological component or technologies with only a "software" component (such as new knowledge or cultural ideas)
Comparison of social groups/classes (i.e. low-income vs high income; rural vs urban; low educated vs high educated; white vs. Hispanic; etc.) or specific focus on a disadvantaged population.	Editorial, commentary, letters to the editor, columns, opinions, viewpoints, or similar
Specifically addresses technology (must include a "hardware" component, such as a tool or instrument)	
Explicit and identifiable application of <i>innovative</i> technology (new technology, or old technology used in a new way)	

<https://doi.org/10.1371/journal.pone.0195447.t001>

Studies deemed relevant by both researchers automatically advanced to secondary sorting. A third researcher, who had not previously worked with the respective subset, then sorted those studies deemed relevant by only one of the two original researchers. Studies deemed relevant by the third researcher also advanced to secondary screening. All relevant studies from the initial screening process were then combined into a single dataset (465 studies) for use during the secondary screening process. During the secondary screening process, three individual researchers independently sorted all studies deemed relevant from the initial sorting process using abstracts (if abstracts were not present, results and conclusion sections were used to

Table 2. Database rationale and search strings.

Database	Rationale	Search string
Medline	As Medline is predominantly medically focused, a more permissive search string was used in order to open for a greater inclusion of medical studies focused on technology.	(health* OR epidemiology OR "health care" OR medic* OR "public health") adj5 (equit* OR inequit* OR equal* OR inequal* OR disparit* OR SES OR "social class" OR education* OR income) adj5 (technolog* OR innovat* OR treatment OR screen) adj5 ("fundamental cause*" OR resource OR diffusion OR innovation*)
Scopus	A stricter proximity search was used with Scopus. This was done to force the search to consider relevant words together.	(health OR epidemiology OR "health care" OR medic* OR "public health") W/5 (equit* OR inequit* OR equal* OR inequal* OR disparit* OR ses OR "social clas*" OR education* OR income) AND (technolog* OR innovat* OR treatment OR screen*) AND ("fundamental cause*" OR resource OR diffusion W/1 innovation*)
ISI Web of Science	Same as Scopus	(health OR epidemiology OR "health care" OR medic* OR "public health") near/5 (equit* OR inequit* OR equal* OR inequal* OR disparit* OR ses OR "social clas*" OR education* OR income) AND (technolog* OR innovat* OR treatment OR screen) AND ("fundamental cause*" OR resource OR diffusion near/1 innovation*)

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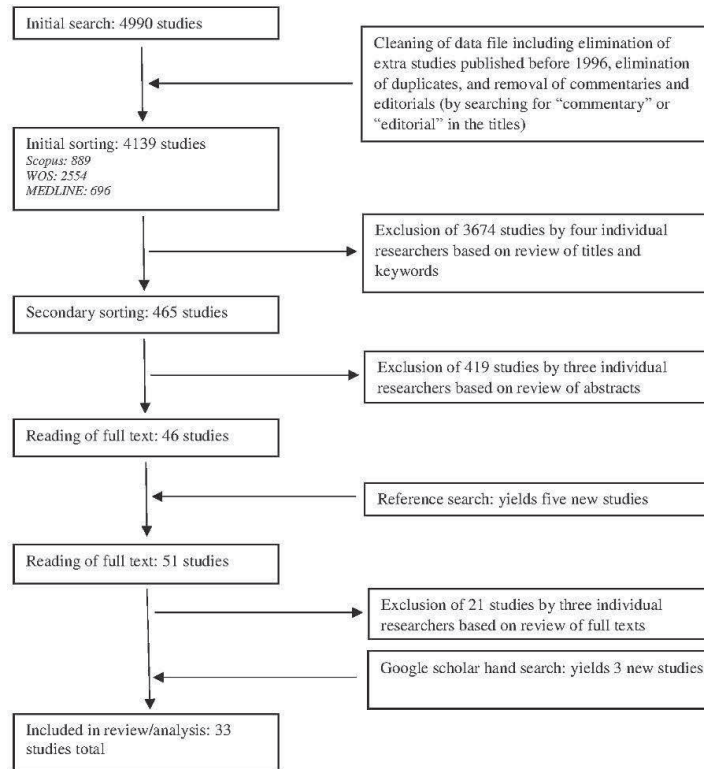


Fig 2. The sorting process.

<https://doi.org/10.1371/journal.pone.0195447.g002>

determine relevance). Only studies deemed relevant by all three researchers advanced to the final sorting process. In the final sorting process, three individual researchers independently read full texts of all included studies. Studies deemed relevant by all three researchers automatically advanced to the data extraction process, while studies deemed irrelevant by all three researchers were automatically excluded. Studies with inconsistent evaluations were discussed by all three researchers until agreement for inclusion or exclusion was met. The resultant studies from this multi-stage systematic sorting process were included in the data extraction process and presented in our results section (Fig 2). The inclusion/exclusion criteria was strictly applied at each stage of the sorting process and articles were excluded if deemed by multiple

researchers to meet exclusion criteria based on title and keywords (stage 1), abstracts (stage 2), or full text (stage 3).

Data extraction was facilitated by the use of a data extraction form designed using procedures outlined by Armstrong et al. [25]. A data extraction form was used to systematically extract information relevant to the aims of this study as well as standard descriptive information. Along with standard title, author and year of publication information, categories included: study location; geographical level (local, regional, national or international); study population; methods used; specific illness addressed; technological innovation addressed/measured; method of implementation for the addressed technology; definition/measurement of social class/inequality; theoretical perspectives; main outcome measures (including health outcomes); overview of main results and conclusions. All full texts were read and analyzed by three individual researchers and individual data extraction forms were then merged into a single, unifying document used for the interpretation and presentation of results. Following typical scoping review methods, methodological quality of the included articles was not assessed systematically, however only peer-reviewed articles were included in our review process [24, 25, 28]. The lack of a systematic analysis of methodological quality is both a weakness and a strength of scoping review techniques. Although it is difficult for a scoping review to draw conclusions based on the quality of the included studies, the strength of a scoping review is in its ability to condense large amounts of material and guide the direction of future research including more comprehensive analyses of the quality of relevant methods [27, 28]. Assurance of methodological quality throughout the search, sorting and extraction processes in the current study however was protected using a systematic design based on a dynamic, reflexive examination process whereby multiple researchers, working at each stage of the process independently, regularly compared results and met to discuss, and reach agreement on, discrepancies [24, 27].

Results and discussion

Overview of included studies

An overview of included studies is offered in Table 3. An overview of excerpts from selected studies representing the formation of the narrative presented in the results and discussion section can be found as a table in supporting information (S1 Table. Forming the narrative—representative excerpts from selected studies). Data from the studies included in our results was most often collected using purely quantitative methods (N = 28), with some articles choosing to use mixed methods (N = 2) or qualitative methods (N = 3). Data collection varied widely between studies, with some studies addressing national populations, while others collected data at the hospital level or individual level. Of the studies addressing a specific illness (N = 18), approximately half of these addressed either HIV or blood/heart related illnesses. Of the technologies addressed by included studies, information/communication technologies (electronic health records and internet portals, e-health, internet-based social networks) and medical services technologies (prescription drugs, medical imaging, and diagnostic and treatment tools) dominated. Measurements of social position and inequality were relatively consistent with commonly used socio-economic variables, varying between income (or GDP in country comparisons), education, and employment status, in addition to geographical location, age, gender, and race/ethnicity. Outcome measures varied widely, however most studies were interested in investigating factors influencing the access, distribution, and/or use of specific technologies by various social groups (for example individual behaviors, facilitators and/or barriers). Some studies, however, addressed consequences associated with poor or limited access to these technologies, including related morbidity and/or mortality.

Table 3. Overview of included studies.

Authors	Country	Study population	Technological innovation measured or addressed	Social class/inequality variable	Main outcome measure(s)
Baum, Newman, & Biedrzycki (2014)	Australia	55 individuals located in areas with low SES	Information and communication technologies (ICT)	Race/ethnicity and socioeconomic status	Access and use of ICT
Bekelis, Missios & Labropoulos (2014)	United States	Patients undergoing any neurosurgical procedure 2005–2010	Cerebral aneurysm coiling	State/region, median income based on zip code	Average risk adjusted intensity of neurosurgical care and average coiling rate per state per year
Butler, Harootyan, & Johnson (2013)	United States	Physicians serving Medicaid and non-Medicaid patients in Arizona.	Electronic health records (EHR)	Insurance status	EHR access and use by general practitioners
Chang & Lauderdale (2009)	United States	Adults aged 20 and over from NHANES II, III, and continuous surveys.	Statin (HMG-CoA reductase inhibitors)	Socio-economic status by income	Income gradients for cholesterol levels over time
Cheng et al. (2012)	United States	Veterans hospitalized with ischemic stroke	Carotid artery imaging	Race/ethnicity	Receipt of carotid artery imaging; race of the patient and minority-serving status of the hospital
Choi & DiNitto (2013)	United States	Low-income homebound adults	Internet based information technology	Age and income	Internet use, eHealth literacy, attitudes toward computer/ internet use
Eddens et al. (2009)	United States	Cancer survivors	Internet/e-Health	Race/ethnicity	Characteristics of cancer survivors, cancer type, form of communication, website characteristics
Ferris et al. (2006)	United States	Adults (under 60) and children with asthma.	Meter dose inhaler	Race/ethnicity and age	Use of meter dose inhalers Insurance status Physician visits and reason for visit
Glied & Lleras-Muney (2008)	United States	Persons diagnosed with cancer	Drug approvals by number of active ingredients approved by FDA	Education	Mortality and drug approvals
Goel et al. (2011)	United States	Patients from an urban, academic primary care practice	Patient health portals	Race/ethnicity, age, gender, education, income	Enrollment in the patient portal, Solicitation of provider advice among enrollees, Requests for medication refills among enrollees.
Goldman & Lakdawalla (2005)	United States	HIV positive, aged 18+ who made at least one visit to clinic in 1996; Men and women aged 28–59 in 1948 residing in Framingham, Mass.	Highly Active Antiretroviral Therapy; beta-blockers	Education	Exposure to drug and health status before and after introduction of technology
Gonzales, Ems, & Suri (2016)	United States	Adults from low-income groups and staff of health care organizations	Cell phones/m-Health	Income	Experiences and challenges to using cell phones and disconnection, as well as related challenges to access healthcare and other social services.
Groeneveld, Laufer, & Garber (2005)	United States	Elderly (over 65) Medicare beneficiaries	Various "emerging" technologies: aortic valve replacement, internal mammary artery coronary bypass grafting, dual-chamber pacemaker implant, vena cava interruption, and lumbar/lumbosacral spinal fusion	Race/ethnicity	Procedure rates using emerging technologies by race
Han, et al. (2010)	Australia	General population with at least one diagnosed chronic medical condition	Information and communication technologies	Socio-economic status	Internet accessibility, socio-economic status by geographical area, prevalence of chronic disease

(Continued)

Table 3. (Continued)

Authors	Country	Study population	Technological innovation measured or addressed	Social class/inequality variable	Main outcome measure(s)
He, Yu, & Chen (2013)	China	Random sample of 71 hospitals from four sites	CT and MRI scanners	GDP at a regional level	Gini coefficient (equity), distribution of CT and MRI, characteristics of CT and MRI machines
Hing & Burt (2009)	United States	Non-federal office-based primary care physicians or providers (PCP)	Electronic health records (EHR)	Payment source; race/ethnicity; median household income	Likelihood of PCPs using EHR
Horvitz-Lennon, Alegria, & Normand (2012)	United States	Medicaid beneficiaries with schizophrenia who had filled at least 1 antipsychotic prescription during the study period	Long-acting injectable formulation of the atypical antipsychotic risperidone (LAIR)	Race/ethnicity and geographic location	Use of LAIR
Kontos, Emmons, Puleo, & Viswanath (2010)	United States	Representative sample of US adults	Internet: social networking sites (SNS)	Race/ethnicity and socioeconomic position	Internet access and SNS use
Korda, Clements, & Dixon (2011)	Australia	Patients (≥ 35 years of age) with a principal or co-diagnosis of acute myocardial infarction (AMI), and with no previous admissions for AMI, between 1989 & 2003.	Coronary procedures: angiography, angioplasty and coronary artery bypass surgery	Socio-economic status by SIEFA index of disadvantage	Receipt of a coronary procedure
Lang & Mertes (2011)	Europe	24 EU member states	E-health	Economic variables (GDP per capita, ICT market value, Broadband access in enterprises)	Effect of various economic, healthcare, and political variables on the implementation of e-health applications
Loureiro et al. (2007)	Brazil	Brazilian states	MRI, computerized tomography, and dialysis machines	Regional socio-economic status by GDP per capita	Distribution of access; number (surplus/deficit) of machines; public vs. private sector differences
Newhouse et al. (2015)	Many	Citizens 16–74 years of age who had used the internet in previous 3 months	Internet based information technology/e-mail	Geographical; education; gender; employment status	Frequency of sending emails to health personnel
Newman, Biedrzycki, & Baum (2012)	Australia	Residents from lower income and disadvantaged backgrounds in South Australia	Information and communication technologies (ICT)	Socioeconomic status	Access, usage and perceived facilitators and barriers to ICT
Ohl et al. (2013)	United States	Veterans in care for HIV infection	Combination antiretroviral therapy (cART)/raltegravir	Geographic (urban/rural); race/ethnicity; age/gender	Raltegravir adoption
Ohlsson, Chaix, & Merlo (2009)	Sweden	Individuals in Skåne region who were issued at least one prescription for statins between July and December 2005	Rosuvastatin (prescription statin)	Socio-economic status	Factors related to outpatient health care practice; physicians' propensity to prescribe rosuvastatin
Perez et al. (2016)	United States	Participants 21 to 35 years of age, had searched the Internet for health information within the past 12 months, and reported at least one barrier to health care services access.	Internet based IT	Education; recruitment from sites offering/not offering social services	Internet search behavior, strategies and processes
Polonijo & Carpiano (2013)	United States	Adolescent girls (age 13–17) and their parents/guardians	HPV vaccine (cervarix/gardasil)	Socio-economic status; race/ethnicity	Parental knowledge of the vaccine; health professional's recommendation of HPV vaccination; actual uptake, and finishing, of the vaccine
Rubin, Colen, & Link (2010)	United States	HIV positive black and white men and women between the age of 15 to 64	Highly active antiretroviral therapy	Socio-economic status; race/ethnicity	HIV/AIDS mortality before and after the introduction of highly active antiretroviral therapy

(Continued)

Table 3. (Continued)

Authors	Country	Study population	Technological innovation measured or addressed	Social class/inequality variable	Main outcome measure(s)
Slade & Anderson (2001)	Many	OECD countries between 1975–1995	MRI machines, CT scanners, kidney transplants, liver transplants, and hemodialysis patients	GDP per capita	Availability and utilization of technology
Stanley, DeLia, & Cantor (2007)	United States	Individuals at risk for sudden cardiac death (SCD)	Implantable cardioverter defibrillator	Race/ethnicity	ICD use and utilization
Wang et al. (2010)	Taiwan	Osteoarthritis patients (≥ 60 years of age) who had undertaken at least one outpatient visit for osteoarthritis	NSAIDs	Income	Treatment incidence
Woolf et al. (2007)	United States	General population (adults 18–64 years of age)	General technological innovations	Education	Age-adjusted mortality
Zibrik et al. (2015)	Canada	Participants from Chinese and Punjabi public health education events	E-health: online tools for health education, communication and self-management	Ethnicity/immigrant status, age, gender, income, and education	e-health literacy

<https://doi.org/10.1371/journal.pone.0195447.t003>

Addressing classification and measurement challenges: Towards a more precise terminology

Social inequality. All variables used in included studies to address, define and measure social position acknowledge that these variables represent various social groups, or classes, that live in relative advantage/disadvantage to one another. These variables can be divided into three distinct approaches. The first approach is characterized by a distinction between selected social groups based on fixed (or ascriptive) factors. These studies use age, gender and/or race/ethnicity to define and measure differences between social groups. The second approach is characterized by social position determining an individual's control of various flexible resources that are to a relative degree amendable [15]. These studies generally stratify social position based on socio-economic variables such as education, income, and insurance or employment status. Unlike the two aforementioned approaches, the third approach is distinguished by the characteristics of place [29]. These studies use geographic location as a measure of social stratification, often defined as (but not limited to) a distinction between rural and urban settings.

These distinct approaches are similarly used to investigate social inequalities, however it is possible to question whether these distinct approaches can be used interchangeably to understand variations in the distribution of population health and innovative health technologies. Although SES may, for example, include various measures such as education, income, and occupational status, used alone or in combinations, one could question whether the mechanisms connecting education to health and technology are the same as the mechanisms connecting occupation or insurance status to health and technology. In relevant literature, such reflections are by and large missing, and very different measures of social position are often treated and interpreted similarly, which may affect the applicability and usability of results [30]. The implications of choosing one approach over another may have consequences on both theoretical and practical understandings of the specific social factors that influence access and use of innovative health technologies. In the studies included in our analysis, it is possible to observe variations in measured inequality based on chosen variables. The variation in results from these studies illustrate that whether or not inequalities in access and use of innovative health technologies are observable are dependent on the approach used to measure these

inequalities and that common measures of social inequality in health cannot be used uncritically.

Our findings, however, may suggest that variations in measurement techniques are, in part, rooted in cultural or scientific traditions. It is interesting to note, for example, that although many of the studies from North America and Australia used a variety of approaches to measuring social inequality, race/ethnicity was often included. Race/ethnicity was, however, never included as a variable in collected studies originating from European, Asian, or South American countries, which instead favored the use of various measures of socio-economic status, such as income or education. Our results do not provide a clear explanation to this finding, but one may question whether this is due purely to availability of data or to cultural and historical factors, where race and ethnicity are more strongly associated with social stratification and class positions in North America and Australia [31, 32]. Regardless, the previous findings raise important questions regarding the extent to which social inequalities in access and use of innovative health technologies are dependent on the approach used to measure and define social groups, which must be critically addressed in future research.

Innovative health technologies. Although it is possible to broadly categorize technologies in included studies by type, a potentially more informative method of categorizing these technologies from a social inequalities in health context is by variations in access and use. Using an approach similar to those presented by Cotterman and Kumar [33], and a focus on level of perceived end-user control, it is possible to propose a division of technologies into three main categories (see Fig 3): technologies accessed and used directly by the end user (type 1 or *direct end-user technologies*), technologies used by the end user but accessed through someone other than the end user (type 2, or *direct-use gatekeeper technologies*), and technologies accessed and

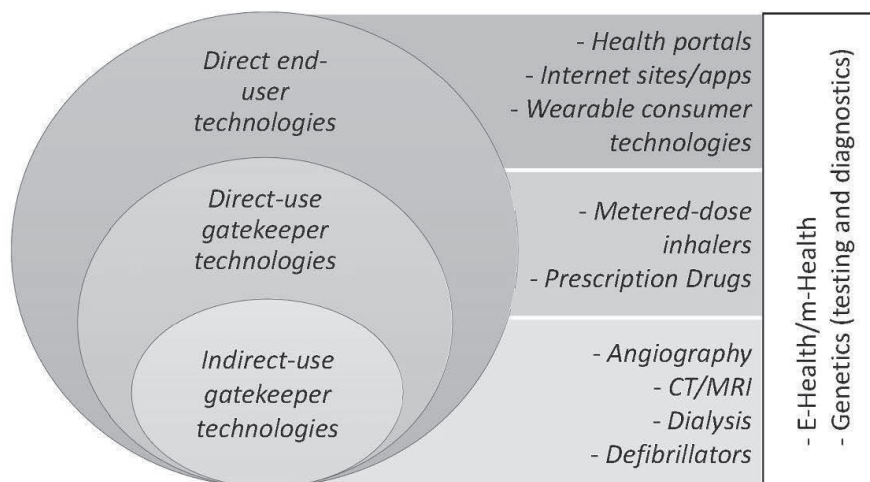


Fig 3. Classification of technologies.
<https://doi.org/10.1371/journal.pone.0195447.g003>

used by someone other than the end user (type 3, or *indirect-use gatekeeper technologies*). In this case “end user” is defined as the individual, or group of individuals, for which the technology is developed. End users generally do not include individuals who develop, operate, or distribute these technologies, unless these individuals are also end users (the operator of a direct end-user technology, for example, is also the end user). As the name implies, “gatekeepers,” in this case, are individuals that guard access and eventual use of technologies by end users [13].

In the case of indirect-use gatekeeper technologies (type 3) and direct-use gatekeeper technologies (type 2), end-users are dependent on gatekeepers in order to gain access to these technologies. Korda et al. [20], for example, investigated the use of a number of coronary procedure technologies dependent on the expertise of health care personnel in which end users have very little direct control over the use and administration of these types of technologies [20, 34]. The technology examined by Rubin et al. [35] (highly-active antiretroviral therapy) differed in that, although access is dependent on a physician, use of the technology is significantly dependent on behavior by the end-user. Results by both Korda et al. [20] and Rubin et al. [35] demonstrate that, after the initial adoption of these technologies, social inequalities in health grew, regardless of whether the use of these technologies was dependent on end user behavior and, furthermore, regardless of the fact that these technologies must be accessed by way of trained health personnel. Results by Korda et al. [20] however also suggest that these inequalities may decline over time, as the adoption by lower SES groups increases.

“The SES inequalities in diffusion observed for angiography and CABG are consistent with the lag in diffusion/inverse inequality hypothesis—for both these procedures, rates peaked earlier in the higher SES patients than the lower SES patients resulting in inequalities, which then disappeared over time. . .”[20, 36]

Similar findings are corroborated by He et al. [37], Ohl et al. [38], and Stanley et al. [39]. Moreover, results by Goldman and Lakdawalla [40] demonstrate that complicated treatment regimens increase social inequalities in health while simplifying treatment regimens reduce inequalities, illustrating the dynamic complexity of the relationship between access and use of innovative technologies and variations in social inequalities in health.

“Simply by improving the productivity of healthcare, new technologies can widen disparities across socioeconomic groups. However, new treatments that simplify the production of health and reduce the importance of patient effort work in the opposite direction. . .complex new treatments for HIV appear to have increased disparities among HIV+ individuals, while pharmaceutical breakthroughs in the treatment of hypertension made self-management less important and coincided with a contraction in disparities. . .”[40]

Nevertheless, the results highlighted above suggest that SES influences variations in the use of innovative technologies by end users even when access is dependent on a “gatekeeper”.

Direct end-user technologies (type 1), contrary to direct-use gatekeeper (type 2) and indirect-use gatekeeper technologies (type 3), are directly accessed and used by end users. The access and use of these technologies is assumed largely dependent on individual agency, or in other words, the assumption that individuals are equally able to consciously make decisions to access or use these technologies for purposes of influencing health. However, the studies included in our results consistently demonstrated that access and use of these technologies was far from equal. Baum et al. [41], for example, demonstrated that low socio-economic groups have restricted access and use of digital information and communication technologies that, in

turn, affect access to a range of social determinants of health, creating a vicious cycle of disadvantage and poorer health.

“The educational opportunities to acquire fundamental literacy also shape health literacy, which therefore in turn affects people’s ability to improve their health status and health outcomes. This disadvantage is compounded because digital literacy is increasingly a pre-requisite for health service delivery and access to health information.”^[41]

Gonzales et al. ^[42] indicate that access to technologies for disadvantaged groups is unstable, and can be regularly disrupted, suggesting that simply measuring access to technology adoption across socioeconomic groups ignores the possibility that unstable access—or unequal use—can have large consequences on social inequalities in health. Perez et al. ^[43] support these results, further demonstrating that purely having access to a particular technology does not guarantee equal use. In fact, an increase in social inequalities in health after the implementation of health technologies is often demonstrated by studies included in our results. Importantly, regardless of findings suggesting that these inequalities will decrease as access to these resources becomes more universal, results from included studies illustrate that access to resources does not necessarily eliminate the (re)production of social inequalities in health.

Unfortunately, our results do not clearly illustrate whether any one of the categories of technologies highlighted in included studies has the potential to influence social inequalities in health to a greater degree than another. Our findings do, however, illustrate a complex relationship, suggesting that the pathways and mechanisms through which inequalities increase or decrease over time vary depending on the factors that influence *both* access and use, as well as type, of these technologies. Furthermore, it was rare for studies included in our results to explicitly measure health outcomes related to the access or use of these technologies. Therefore, studies rarely addressed or investigated specific mechanisms or pathways linking health technology access and/or use to unique explanations of variations in health. Consequently, it is clear that more research is needed to further understand these complex mechanisms.

It is also clear that some important technologies are missing from the literature. The technologies addressed by studies included in our results focus predominantly on technologies designed and used in health care services. Included in this collection of technologies is a growing focus on the internet and internet-based tools, as the use of these technologies also become an integrated resource in health care services ^[3, 4, 42, 44–46]. However, as various researchers have highlighted in recent years, technologies that have the potential to greatly influence health and social inequalities in health are not limited to those found in health care services ^[3, 6, 7, 11]. These technologies include innovations used to monitor and control individual health, such as genome sequencing and lifestyle technologies (wearable devices and personal, digital applications, for example). It is, therefore, clear that future research investigate the potential implications of these types of innovative technologies on social inequalities in health.

Discussing potential pathways: Conceptualizing access and use

The studies included in this article exhibit varying approaches for conceptualizing the relationship between innovative health technologies and social inequalities in health. Studies discussing a perspective grounded in individual access and adoption of these technologies ^[18, 20, 39, 47–49] often refer to the diffusion of innovations theory, which categorizes adopters of innovations based on individual characteristics related to social positioning ^[13]. These studies use this theory to establish that lower SES groups are slowest to adopt, and therefore benefit less from, innovative health technologies. However, as access to these technologies “diffuses”

throughout the population, and lower SES groups begin to adopt, these inequalities begin to diminish and may potentially disappear [18, 20, 37–40, 47].

“Income gradients were positive in an era prior to statins, but became negative in the period subsequent to the advent and dissemination of statins. While the more advantaged were once more likely to have high levels of cholesterol and LDL, they are now definitively less likely. Additionally, exploratory analyses suggest that income is positively associated with statin use accounting for clinical need. . . While resources affect access to technologies, some technologies can also affect resources, lessening the productivity of various health inputs.” [18]

Although this perspective assumes that the unequal adoption of these technologies is relatively unavoidable, they argue that the extent to which these innovations influence social inequalities in health is subject to the rate at which these technologies diffuse.

Building on this explanation, a number of studies [18, 19, 35, 47, 50] draw attention to the fundamental cause theory, which suggests that individuals “deploy” flexible resources, “such as money, knowledge, power, prestige, and beneficial social connections. . . to avoid risks and adopt protective strategies” [15]. These studies use this theory to illustrate that innovative health technologies are accessed to a greater degree by individuals of higher social position.

“The SES–HIV/AIDS mortality association, although present in the pre HAART period, was greater in the peri-HAART period and greater still in the post HAART period, even when race and other factors were controlled. . . These findings are consistent with fundamental cause theory, which holds that when innovations render a disease more treatable, the benefits of such developments are not evenly distributed.” [35]

Explanations referring to the fundamental cause theory and the diffusion of innovations, however, often assume that as innovative health technologies become more evenly distributed—or adopted—across social strata, so too will their benefits.

The above perspectives are contrasted by studies presenting social inequalities more specifically as a consequence of variations in use of innovative health technologies. These discussions often refer to explanations grounded in theories related to health literacy [43, 44, 51, 52] or digital divide [41, 42, 46, 53–55]. While health literacy refers to an individual’s ability to assess, understand, and use information critical to using health services and making decisions regarding health [52], digital divide refers to variations in the use of digital technologies between social strata [54]. These studies suggest that, regardless of access, inequalities exist due to the characteristics of social position determining an individual’s proficiency in using innovative health technologies to benefit health. Perez et al. [43], for example, demonstrate that, regardless of access to internet-based tools, health information searching and processing strategies vary by SES, benefitting higher educated individuals.

“When confronted with a specific set of symptoms, higher-SES participants tended to use search strategies that branch out—the exploration of conditions they expect contribute to the symptoms and systematically exploring offshoots of that condition, such as related conditions or symptoms. Lower-SES participants used heuristics to prune the scope of their Internet search—i.e., heuristics to ignore or remove search topics believed to be superfluous to the condition.” [43]

Results by Zibrik et al. [52] and Newman et al. [55] illustrate the significance of socioeconomic and cultural factors influencing variations in the quality of use of innovative health technologies, favoring individuals of higher social position. These studies emphasize the experiences of individuals with innovative health technologies, demonstrating that variations in user experience as a result of social positioning has the potential to undermine the benefits assumed by universal access.

The above theories, however, seem to suggest that these inequalities are driven by the potential of social positioning to provide individuals with the ability to make conscious choices and “consume” these resources [56], assuming that these choices are made consciously and with motivated intent to improve health [23]. However, numerous studies included in our results highlight the importance of mechanisms at the institutional and political levels that may significantly influence the distribution, in access and use, of innovative health technologies across social strata [14, 34, 37, 45, 57–64]. Many of these studies demonstrate that patterns of adoption and use of innovative health technologies at the level of the health care institution may significantly influence the potential of these innovations to benefit the health of end users regardless of individual choice or intent.

“Patients admitted to non-minority-serving hospitals were more likely to receive carotid artery imaging than patients admitted to minority-serving hospitals. . . the predicted probabilities of receiving carotid artery imaging were similar between white patients and black patients at non-minority-serving hospitals. . . However, the predicted probabilities among white patients and black patients at minority-serving hospitals were both significantly lower than white patients at non-minority-serving hospitals.” [34]

Furthermore, a study by Lang and Mertes [62] demonstrated that the prevailing orientation of dominating political parties can influence how innovative health technologies are accessed and used at the State level, resulting in variations in the distribution of these resources. In a similar discussion, Han et al. [60] refer explicitly to the social determinants of health theory, which describes the unequal distribution of health as a result of socioeconomic conditions that are largely constructed by social policy [65], to stress the significance of a geographical patterning of health influencing variations in access and use of innovative health technologies.

Due to a focus on single technologies, however, many of the perspectives discussed above fail to address the potential influence that the rapid, uninterrupted development of new technologies may have on the reduction or (re)production of social inequalities in health. It could be suggested that the cumulative effects of multiple technologies adopted over time is itself a mechanism for (re)producing health disparities. In this case, potential mechanisms could be related to windfall benefits [13], which are benefits afforded by early adopters (high SES individuals) that accumulate over time, or Bourdieu’s theories of capital and symbolic violence [66], where the development and implementation of innovative technologies by high SES groups may reinforce social stratification. Baum et al. [41] demonstrate that Bourdieu’s social theories are a relevant addition to a discussion of innovative health technologies and social inequalities in health, drawing attention to the ways that innovative health technologies potentially influence the interaction of social, cultural, and economic capital to reproduce inequalities in health. They conclude that “some people are being caught in a vicious cycle whereby the inability to make beneficial use [of innovative health technologies] reinforces and amplifies existing disadvantage” [41].

The results of this study, therefore, seem to suggest that understanding the pathways through which various innovative health technologies reduce or (re)produce social inequalities in health is context dependent. Theories focused on the dependency of individual resources,

such as fundamental cause theory, may therefore be most appropriate for understanding socially stratified variations in the access and use of direct end-user (type 1) technologies. Interestingly enough however, studies referring to these theories generally address direct and indirect-use gatekeeper (types 2 and 3) technologies, allowing one to question the merit of these explanations. Conversely, mechanisms at the institutional and political levels would thus seem most appropriate in explaining direct and indirect-use gatekeeper (types 2 and 3) technologies, where the advantages of these technologies are often poorly recognized by individuals of lower social status or where access is limited by gatekeepers (for example, political or institutional agents). In order to better understand social inequalities in health, these contextual variations draw attention to the need for critical distinctions between technologies based on how, and in what context, these various technologies are accessed and used. This may include a stronger focus on understanding the role of institutions and accompanying theories that explain complex mechanisms influencing the distribution of population health [1].

Limitations

Some limitations not addressed earlier in this study are worth discussing. First, although the choice of search terms was purposefully broad and systematically identified using relevant literature, it is possible that the ability to collect relevant literature from a larger breadth of research fields and traditions could have been limited. This is due to the possibility that the researchers' previous relation to the fields of sociology and health limit the familiarity, and therefore inclusion, of relevant terms or language used in the fields of technology and innovation. Second, the decision to exclude grey literature, including books, reports, etc., may have led to the exclusion of relevant literature, which could have possibly been used to widen or further support perspectives presented in the results. However, this choice was made with consideration for a purposeful selection of empirical, peer-reviewed studies using original data analyses. The goal here was to increase the probabilities of including relatively high quality research and excluding the possibility of grey material that is lower in quality and neither peer-reviewed nor includes original analyses. Furthermore, as grey literature includes reports and documents often drafted by order of political or special interest organizations, it is more difficult to assess underlying biases that would negatively bias our results. Third, the decision to exclude studies focused on treatment techniques within health services may have excluded some relevant literature. Very often, treatment techniques are dependent on the use of a specific technology. However, had the current study included literature focused on treatment techniques, without a specific focus on the technology used in this treatment, it would have been up to the authors to investigate whether or not each treatment technique included the use of an innovative technology, introducing bias as well as a very problematic assessment process. Furthermore, the inclusion of such studies would have shifted the focus of the current study from that of one focused on novel perspectives related to technology and public health to one focused on the relatively well established field of social inequalities in treatment and health services. The authors, therefore, felt that the inclusion of such studies was out of the scope of the current study and would have fundamentally transformed the current study's aims and contribution to the scientific literature.

Conclusions

This review was interested in systematically investigating existing literature that explores the influence of innovative technologies on social inequalities in health. The results of this study offer interesting perspectives worth consideration, with implications for further investigation of the influence of innovative health technologies on social inequalities in health. This study

questions established scientific measures of social inequality, where various measurements (such as race/ethnicity, income, education, geography, etc.) are often used interchangeably to investigate variations in access and use of innovative health technologies. Results illustrate that the choice of measurement has the potential to bias findings and, therefore, significantly influence the understanding of complex relationships between innovative health technologies and social inequalities in health. Furthermore, this study proposes that a social inequalities perspective may benefit from an understanding, and differentiation, of technologies based on how these technologies are accessed and used by end users. Factors and mechanisms that influence access, for example, may differ from factors and mechanisms that influence use. It is clear that it is not enough to solely focus on the factors and mechanisms that influence unequal access and therefore ignore how variations in use importantly shape social inequalities in health. It is, moreover, not enough to focus attention solely on health care services technologies but, importantly, to investigate emerging technologies in lifestyle health, genomics, and the increased use of personalized devices in health. Furthermore, a deeper understanding of social inequalities in health and innovative health technologies is dependent on distinguishing between a perspective focused on individual resource use, which often draws a questionable causal relationships between SES, technology access/use, and health outcomes, and a perspective focused on mechanisms that are more dependent on social and institutional structure than on individual agency. Although the studies included in our results generally suggest that the implementation and adoption of new technologies (re)produce SES and class-based social inequalities in health, some results indicate that these technologies can, in fact, reduce inequalities over time. Additional research, based on the findings discussed in this study, are needed, however, to reliably establish these conclusions. As much of the current research is dominated by the use of quantitative methods of social epidemiology, additional research may benefit from an increased use of qualitative, sociological methods in order to further investigate mechanisms and pathways leading to the (re)production of social inequalities in health as a result of innovative technologies [8, 30]. It is, nevertheless, becoming increasingly important to investigate the social implications and consequences of a society increasingly influenced by technological innovations, including the ways in which these technologies may influence the unequal distribution of health as a human right.

Supporting information

S1 Table. Forming the narrative-representative excerpts from selected studies.
(DOCX)

S1 File. Original data file.
(TXT)

S1 PRISMA Checklist.
(DOC)

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The diffusion of innovative diabetes technologies as a fundamental cause of social inequalities in health. The Nord-Trøndelag Health Study, Norway

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Abstract This study investigates patterns of adoption and diffusion of innovative health technologies by socioeconomic status (SES) in order to assess the extent to which these technologies may be a fundamental cause of health-related inequalities. Quantitative analyses examined SES-based inequalities in the adoption and diffusion of diabetes technologies. Diabetes data from three panels of the Nord-Trøndelag Health Study (HUNT), Norway, were combined with income and education data. Cross-sectional and longitudinal regression analyses were used to examine relevant inequalities. Cross-sectional analyses suggest often present SES-based gradients in the adoption of diabetes technologies, favouring high-SES groups. Statistically significant differences ($p \leq 0.05$) were most often present when technologies were new. In a cohort followed from 1984 to 1997, high SES individuals were more likely to adopt insulin injection technologies but, due to modest sample sizes, these inequalities were not statistically significant after adjusting for age, gender, and duration of illness. Moreover, compared to low SES individuals, high SES individuals are more active users of diabetes technologies. Results suggest that SES-based variations in access and use of innovative health technologies could act as a mechanism through which inequalities are reproduced. This study provides a discussion of mechanisms and a methodological foundation for further investigation.

Keywords: social inequality, health, diabetes, technology, innovation, HUNT

Introduction

Background and theory

As public health becomes increasingly commodified, innovative technologies are an increasingly important resource through which treatment, care and promotion of human health is

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bought, sold and traded (Casper and Morrison 2010, Gabe and Monaghan 2013, Lupton 2015, Piot 2012). Market forces have been shown to strengthen the typical inverse relationship between the quality of medical care and need, where higher quality care is generally received by those in a position of least need (Hart 1971). This may be further strengthened by the legitimisation of medical technologies as a means of promoting a patient empowerment (i.e. individual responsibility) discourse in support of 'realising system objectives of increased efficiency and reduced expenditures' (Øversveen 2020, Weiss 2019). The importance of traditional forms of capital – such as economic, symbolic, social or cultural – on the ability to exploit advantages resulting from the adoption of innovative technologies provides a potential mechanism for the (re)production of imbalances in power, and therefore social inequalities (Gabe and Monaghan 2013, Grenfell 2014, Rogers 2003). There is increasing support for the argument that the power needed to attain access to, and proficiently exploit, modern medical technologies in a systemic environment increasingly pressured by economic incentives is dependent not just on individual purchasing power (i.e. economic capital), but on the resources and advantages afforded by high social status (i.e. cultural, social and symbolic forms of capital) (Øversveen 2020, Weiss 2019).

These concerns have become particularly relevant as technological advances in the health sector coincide with increasing inequalities in and around health (Beckfield *et al.* 2015, Mackenbach 2012, Marmot 2015). Efforts to reduce health inequalities have been disappointing, due partly to a relative lack of understanding of mechanisms and meta-mechanisms responsible for (re)producing inequalities (Freese and Lutfey 2011, Mackenbach 2012, Phelan and Link 2013). Link and Phelan's Fundamental Cause theory (FCT) offers a prominent explanation, positing that advantages associated with money, power, prestige, knowledge and social connections are deployed by individuals to avoid risk factors associated with illness or death (Phelan and Link 2013, Phelan *et al.* 2010). While various empirical studies of FCT have supported its various premises, many of the theory's tests have focused on the role of advantaged access to particular health technologies as a means of improving health status despite FCT's apparent inattention to established research in and around technology and innovation (Chang and Lauderdale 2009, Freese and Lutfey 2011, Link *et al.* 1998, Lutfey and Freese 2005, Masters *et al.* 2015, Phelan and Link 2013, Phelan *et al.* 2004). Other researchers have raised arguments in an attempt to further the theory's development in various directions (Clouston *et al.* 2016, Freese and Lutfey 2011, Lutfey and Freese 2005, Øversveen *et al.* 2017, Veenstra 2017), with some focusing on the theory's relationship with the relevant science of innovation and technology (Chang and Lauderdale 2009, Clouston *et al.* 2016, Weiss *et al.* 2018).

Further understanding the role that diffusion processes have on reproducing inequalities in accessing and exploiting technological innovations in health, may also provide a deeper understanding of the pathways through which fundamental causes of social inequalities manifest in the modern techno-society. To this end, recent research has applied a diffusion of innovations perspective to explore premises related to the FCT in more detail (Chang and Lauderdale 2009, Glied and Lleras-Muney 2008, Korda *et al.* 2011). Originally developed and elaborated on by Rogers, the diffusion of innovations theory maintains that novel ideas, practices or objects are adopted earliest by individuals of higher social position, whom thereafter accumulate advantage resulting from these innovations (Rogers 2003). In the case of health-related innovations – such as net-based applications, gene technology, or new treatment or diagnostic tools – this could mean a widening of social inequalities. However, the influence adoption of innovations in health has on changes in social inequalities may depend significantly on the type of health technology in question (Goldman and Lakdawalla 2005, Weiss *et al.* 2018). Research would seem to benefit from further exploring various types of technology used to

prevent, diagnose, treat or manage illness using a single cohort over time. Furthermore, additional analyses are needed to test the validity of these relationships even in a context of strong welfare regimes using well-established single-payer universal healthcare systems.

Aims

This study investigates whether innovative health technologies, and associated improvements in disease management, diffuse unequally by socioeconomic status (SES), giving rise to inequalities that are stronger when technologies are new. In order to achieve this objective, this study's aims were threefold: (i) to measure the probability of adopting a new diabetes technology (i.e. diffusion patterns) based on education and income; (ii) to investigate use patterns of diabetes technologies based on education and income (the second aim differs from the first in that the latter is not just concerned with whether or not a technology is adopted, i.e. accessed for use, but instead to investigate the interaction between adopter and technology to identify variations in the ways in which the technology is used, i.e. by the user, to exploit its potential benefits) and; (iii) to investigate whether potential variations in SES-based adoption and diffusion have an effect on inequalities in relevant health outcomes.

Diabetes as a case

Diabetes is a major cause of morbidity and mortality, affecting a growing number of individuals internationally (including Norway, where rates have increased from 2.5% in 2004 to 3.5% in 2016) (Stene *et al.* 2017, World Health Organization 2016). Current international research has documented increased prevalence, poorer regulation and control, and increased mortality for low SES groups, even in nations with strong universal healthcare systems (Agardh *et al.* 2011, Grintsova *et al.* 2014, Ricci-Cabello *et al.* 2010, Scott *et al.* 2017, Stene *et al.* 2017). Furthermore, effective management and control of diabetes is very dependent on active self-management and the use of technologies (Franklin 2016, Lutfey and Freese 2005, Øversveen 2020, Ritholz *et al.* 2007, Scott *et al.* 2017). Although user perceptions of these technologies differ, research highlights that many of these technologies have documented improvements in outcomes for both type 1 and type 2 diabetes (Franklin 2016, Naranjo *et al.* 2016, Ritholz *et al.* 2007). For example the adoption of continuous glucose monitors and insulin pens have demonstrated substantial improvements in glycosylated haemoglobin (HbA1c) levels, a form of haemoglobin used to identify 90-day average plasma glucose, when compared with older technologies (Anderson and Redondo 2011, Asche *et al.* 2010, Ritholz *et al.* 2010). This is supported by the current research establishing a variation in HbA1c levels of 0.5 per cent as clinically significant (Lenters-Westra *et al.* 2014).

Norwegian context

Norwegian health care is characterized by a predominantly public funded universal system of coverage where only 15 per cent is funded through out-of-pocket payments (Ringard *et al.* 2014). Out of pocket fees are used on co-payments for general practitioner (GP) and specialist visits, dental care, and pharmaceuticals, but are generally fixed at the national level and often included in an annual out-of-pocket cap. Inpatient care at public hospitals in Norway is free (Vikum *et al.* 2013). The largely semi-decentralized structure of health care in Norway administers specialist services at the state level (since 2002) through four Regional Health Authorities and primary care services at the municipality level (Ringard *et al.* 2014). Since 2001, nearly all Norwegian citizens have been assigned to specific regular GPs, who act as gatekeepers for specialist and elective services (Vikum *et al.* 2013).

Recent reforms include efforts to decentralize services (first half of the study period), efforts to increase efficiency of service delivery, and structural transformations focused on both

increasing coordination between service providers and increasing patient autonomy (second half of the study period) (Ringard *et al.* 2014). Wait times, however, remain relatively long, geographical variations (rural/urban) persist, and despite very low levels of inequality compared to other EU nations, social inequalities in health are an issue of concern (Ringard *et al.* 2014).

Diabetes specialists are ultimately responsible for prescribing the use of State-insurance-covered technologies. These decisions, however, are often made in collaboration with other health personnel close to the potential user (i.e. patient) as well as in discussion with the potential user. National guidelines exist for prescribing State-insurance-covered technological aids, however, are often used in practice as open recommendations that are interpreted and implemented based on conditions and priorities specific to the local institution of care (i.e. variation between hospitals and between regions), as well as conditions and characteristics specific to the potential user. Importantly, however, all these technologies are also available in some form on the private market and therefore can be bought and used by individuals with sufficient capital (financial, social, cultural), particularly when considering that not all parts of these technologies have always been covered by State insurance schemes.

Methods

Data sources

The Nord-Trøndelag Health Study (HUNT) is a county-level public health study started in 1984 with the objective of surveying and measuring the health of the entire county's adult population (≥ 20 years of age). The survey's database currently includes data from three cohort panels during 1984–1986 (HUNT 1, $N = 77,212$ or 89% of those invited), 1995–1997 (HUNT 2, $N = 65,237$, 69.5%), and 2006–2008 (HUNT 3, $N = 50,807$, 54.1%) (Krokstad *et al.* 2012). The total population of the county changed by less than three per cent over the 25-year span of the study, and the region is generally considered to be representative of the country as a whole (Krokstad *et al.* 2012, Vikum *et al.* 2013). The survey provides a total of 166,758 observations available from 97,251 individuals who have answered either one ($n = 48,414$), two ($n = 28,167$), or all three ($n = 20,670$) of the surveys (Vikum *et al.* 2013). For this study, survey data were merged with education and income data from the national registry, obtained via Statistics Norway (SSB).

Technologies

All three HUNT surveys include an additional diabetes survey for those who report once or currently having diabetes on the general survey. Table 1 provides an overview of the variables included in this study from each HUNT survey.

The various technologies included in this study, and their approximate time of adoption, are presented in Figure 1. These technologies represent broad categories of diabetes technologies. Although other broad treatment methods for diabetes were available at the time of these surveys, they were either non-technology dependent (e.g. lifestyle changes) or marginal technologies with very few users (limiting potential analyses). Time of adoption for these technologies was estimated using relevant literature as well as historical reference via consultation with the Norwegian Diabetes Association (dating back to 1948) and reference to the 1988 Norwegian guidelines for diabetes treatment (Clarke and Foster 2012, Midthjell *et al.* 1988, Palanker *et al.* 2011, Selam 2010).

Table 1 Variables used from the three cross-sectional surveys in the Nord-Trøndelag Health Study (HUNT), Norway. Dates for each HUNT survey represent start/end period for data collection

HUNT 1 (1984–1986)	Measuring urine sugar at home Measuring blood sugar at home
HUNT 2 (1995–1997)	Injection of insulin at home (using syringe) Measuring blood sugar at home using strips Measuring blood sugar at home using a digital device Injection of insulin at home using a syringe Injection of insulin at home using a pen Injection of insulin at home using a pump
HUNT 3 (2006–2008)	Frequency of blood glucose measurements (weekly) Measuring blood sugar at home (any method) Injection of insulin at home using a pen Injection of insulin at home using a pump Use of laser eye treatment Frequency of blood glucose measurements (weekly)
Across all HUNT surveys	Length of disease history

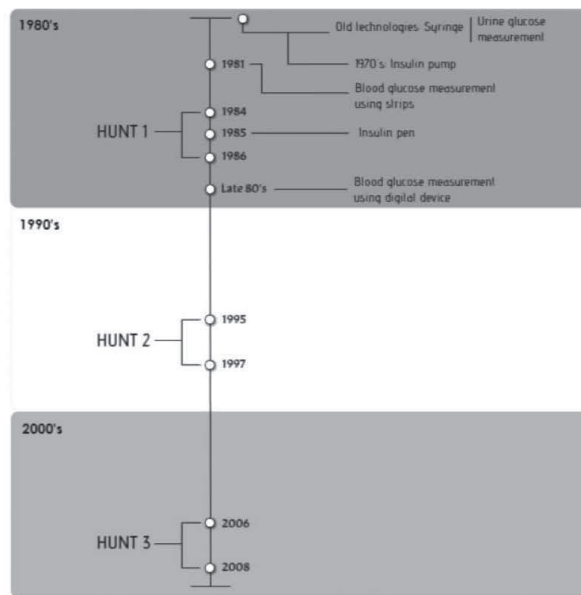


Figure 1 Reported use of diabetes technologies by participants in the Nord-Trøndelag Health Survey (HUNT), Norway, and their approximate year of adoption in relation to start/end dates for data collection in each HUNT study

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Socioeconomic status

Socioeconomic status was measured using participant education and income. Pensionable income data as the sum of personal income for each year from 1984 to 2008 was used as this was the only income variable available for all years dating back to 1984. Respondents were then divided into high- and low-income groups based on average median yearly income. Education level has been recoded into three groupings, low (lower secondary schooling), medium (upper/post-secondary schooling), and high (university education), based on the National Standard Classification of Education in Norway (NUS) during the period 1984–2008.

Diabetes sample and statistical analyses

Our analyses include individuals who have reported currently or once having diabetes on any one of the HUNT 1 (n = 2248), HUNT 2 (n = 2028), and HUNT 3 (n = 2264) general surveys. Importantly, our analyses are not limited only to individuals with diabetes who have responded on *more than one* of these surveys, as this significantly limited sample sizes (HUNT 1 and 2 n = 524, HUNT 2 and 3 n = 569, HUNT 1–3 n = 137), however, our specific analyses are represented by this limitation (more on this below). Average age of those responding currently or once having diabetes is 69 years for HUNT 1 (SD = 14, min.–max. = 21–100), 66 years for HUNT 2 (SD = 14, min.–max. = 20–98), and 64 years for HUNT 3 (SD = 13, min.–max. = 20–94). Furthermore, of this sample, 44 per cent are male in HUNT 1, 48 per cent in HUNT 2, and 52 per cent in HUNT 3.

Individuals who have responded having diabetes on the general survey are then followed up using a diabetes-specific survey in each HUNT study (HUNT 1 n = 1758, HUNT 2 n = 1630, HUNT 3 n = 1824, HUNT 1 and 2 n = 347, HUNT 2 and 3 n = 387, HUNT 1–3 n = 86). Diabetes was, in part, well-suited for this analysis due to the advantage of similar diabetes surveys spanning all HUNT studies, allowing for relatively simple comparisons of most variables between cohorts. Some exemptions are worth noting, however. Number of years with diabetes diagnoses in the HUNT 1 sample was calculated using the equation ($[birth\ year + age\ at\ time\ of\ survey\ completion] - year\ of\ diagnosis$), whereas variables for number of years with diabetes diagnosis in HUNT 2 and HUNT 3 were previously available in the dataset. The two insulin pen types (disposable and standard) included in the HUNT 2 survey were merged into a single insulin pen variable to simplify comparison with the HUNT 3 survey (which does not distinguish between multiple pen types). Mean group HbA1c values, adjusted for age, were calculated for each SES and technology category (in HUNT 1, averages were calculated using non-fasting capillary glucose due to an absence of HbA1c values). In addition, due to survey question formulation, non-respondents (i.e. missing values) of questions regarding technology use were recoded as non-adopters (i.e. non-users), to differentiate from individuals who

Table 2 *New and old diabetes technologies in each Nord-Trøndelag Health Survey (HUNT), Norway*

<i>Technology type</i>	<i>HUNT 1</i>	<i>HUNT 2</i>	<i>HUNT 3</i>
Measuring urine sugar at home	Old	–	–
Measuring blood sugar at home using strips	New	Old	Old
Measuring blood sugar at home using digital	–	New	Old
Injecting insulin at home using syringe	Old	Old	Old
Injecting insulin at home using pump	–	Old	Old
Injecting insulin at home using pen	–	New	Old

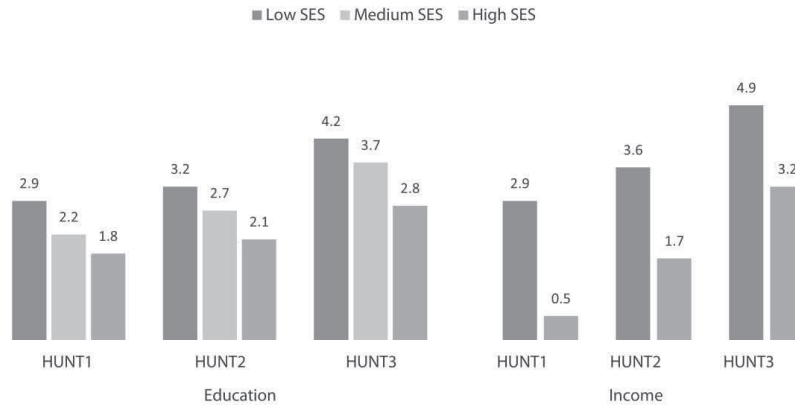


Figure 2 Age standardised* self-reported diabetes prevalence (%) by socioeconomic status in HUNT1–HUNT3. Nord-Trøndelag Health Survey (HUNT), Norway. *Directly standardised towards the total Norwegian population January 1st year 2000

specifically responded using these technologies (i.e. adopters or users). In other words, all individuals who did not specifically report using included technologies were recorded as non-users.

Based on adoption dates and relevant treatment guidelines, Table 2 below presents technologies considered old and new in each HUNT survey:

Analyses include a cross-sectional linear regression plus post-estimation to calculate age-adjusted average HbA1c levels with 95 per cent confidence intervals (95% CI) for each HUNT cohort based on SES and technology type. Furthermore, logistic regression models yielding odds ratios (OR) with 95 per cent CI were specified to examine associations between SES and the use of new technology independently in each cohort (i.e. cross-sectional analyses of HUNT 1–3) as well as in a cohort of adopters versus non-adopters followed from HUNT 1 to HUNT 2 (HUNT 3 data are excluded from this latter analysis as it does not include technologies considered innovative, i.e. adoption after HUNT 2). All analyses were performed using Stata/SE 15.1 (StataCorp 2017).

Results

Inequalities in diabetes prevalence and management

Figure 2 presents age standardised diabetes prevalence rates in each HUNT study based on education and income. Across all HUNT surveys, the majority of individuals that reported currently or once having diabetes are from low SES groups. An educational gradient in prevalence persists across HUNT surveys. Also apparent is the steady increase in total prevalence over the entire study period (2.67%, 2.85% and 3.62% for each HUNT survey, respectively). Some socioeconomic groups, however, seem to disproportionately account for this total increase. When compared with other socioeconomic groups, medium educated and high-income groups account for a larger proportion of this increase over time.

Table 3 presents HbA1c levels for participants with diabetes in each HUNT survey based on SES and technology type, adjusted for age. The data suggest a general decline in average

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Table 3 Mean HbA1c levels by socioeconomic status and type of technology, with 95 per cent confidence intervals (95% CI) and adjusted for age. Nord-Trøndelag Health Study (HUNT), Norway

	HUNT 1 ¹		HUNT 2 ²		HUNT 3 ²	
	HbA1c	95% CI	HbA1c	95% CI	HbA1c	95% CI
Education						
Low	8.40	8.19–8.63	8.20	8.08–8.32	7.21	7.08–7.34
Medium	8.85	8.51–9.20	8.05	7.91–8.18	7.27	7.18–7.37
High	7.91	7.01–8.83	8.00	7.71–8.29	7.14	6.97–7.32
Income						
Low	8.47	8.28–8.66	8.14	8.04–8.24	7.18	7.06–7.29
High	9.16	8.28–10.04	8.06	7.84–8.28	7.27	7.18–7.36
Glucose tech						
Old	9.14	8.85–9.43	8.41	8.07–8.74	7.33	7.25–7.41
New	9.75	9.28–10.22	8.48	8.35–8.60	–	–
Insulin tech						
Old	10.10	9.65–10.55	9.23	8.87–9.59	7.98	7.85–8.11
New	–	–	8.92	8.74–9.09	–	–

¹Non-fasting capillary glucose measurement used as fasting glycated haemoglobin (HbA1c) values unavailable.

²In HUNT 2 and 3 whole blood samples were used to collect fasting HbA1c levels.

glucose levels for all groups over time. Differences otherwise are mostly minor and scattered. The exception is in HUNT 1, where clinically significant (>0.5%) variations in HbA1c levels exist, appearing to favour individuals with high (university) education. In contrast, however, clinically significant variations seem to also favour low-income individuals and users of old glucose technology in HUNT 1.

Inequalities in the use of diabetes technologies

Table 4 illustrates that social inequalities in the use of diabetes technologies exist regardless of technology type or measure of SES and are particularly strong when technologies are new. In HUNT 1, results suggest that high SES groups are generally more likely to use diabetes technology regardless of the type or age of the technology, however, inequalities are strongest for the use of new glucose measurement technology (GMT). Compared with the least educated group, those with medium education had a 1.46 times higher odds of reporting use of this technology, whereas the odds for the highest educated group was 3.25 times higher. The high-income group had 2.68 times higher odds compared with the low-income group. Inequalities for old technologies appear to be statistically non-significant across HUNT 1 results except for the use of old insulin injection technology (IIT), where income inequalities present statistically significant results (OR = 2.26 [1.17–4.39]). Results from HUNT 2 appear to present similar results in that inequalities favouring high SES groups are stronger for new technologies. Educational inequalities in the use of diabetes technologies in HUNT 2 are statistically significant between low and high (but not statistically significant between low and medium) educated for new IIT (OR = 1.82 [1.12–2.94]) and also statistically significant between low and medium (but not statistically significant between low and high) educated for new GMT (OR = 1.77 [1.40–2.24]). Although, in contrast to HUNT 1, low SES groups appear to be generally more likely than high SES groups to use old diabetes technologies (the exception being the high educated group for old glucose technology), all other inequalities in HUNT 2 are statistically non-significant, including all results for income-related inequalities. In HUNT 3, general

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Table 4 Cross-sectional associations between education level and income and use of diabetes technology in the Nord-Trøndelag Health Studies (HUNT), Norway, with odds ratio (OR) and 95 per cent confidence interval (95% CI)

	Old glucose technology		New glucose technology		Old insulin technology		New insulin technology	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
HUNT 1								
Education								
Low	1.00	ref	1.00	ref	1.00	ref	–	–
Medium	1.15	(0.91–1.45)	1.46 ¹	(1.09–1.97)	1.23	(0.88–1.71)	–	–
High	1.43	(0.84–2.43)	3.25 ¹	(1.84–5.75)	1.74	(0.91–3.32)	–	–
Income								
Low	1.00	ref	1.00	ref	1.00	ref	–	–
High	0.72	(0.42–1.25)	2.68 ¹	(1.50–4.79)	2.26 ¹	(1.17–4.39)	–	–
HUNT 2								
Education								
Low	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Medium	0.71	(0.44–1.15)	1.77 ¹	(1.40–2.24)	0.96	(0.56–1.65)	1.30	(0.97–1.75)
High	1.29	(0.61–2.75)	1.51	(0.98–2.31)	0.76	(0.26–2.19)	1.82 ¹	(1.12–2.94)
Income								
Low	1.00	ref	1.00	ref	1.00	ref	1.00	ref
High	0.78	(0.38–1.60)	1.15	(0.82–1.62)	0.56	(0.22–1.41)	0.90	(0.61–1.35)
HUNT 3								
Education								
Low	1.00	ref	–	–	1.00	ref	–	–
Medium	1.10	(0.84–1.44)	–	–	1.16	(0.86–1.55)	–	–
High	1.18	(0.77–1.78)	–	–	1.45	(0.97–2.16)	–	–
Income								
Low	1.00	ref	–	–	1.00	ref	–	–
High	1.17	(0.87–1.58)	–	–	0.89	(0.66–1.19)	–	–

Adjusted for age, gender and length of illness.

¹Signifies statistical significance.

inequalities in the use of technologies in bivariate analyses, favouring high SES groups, seems to reappear in spite of these technologies being considered old and regardless of the type of technology (the only exception being inequalities between income groups for old insulin technologies, which suggests greater use by the low-income group). However, all these inequalities are statistically non-significant after controlling for age, gender and length of illness.

Results, in general suggest that, when compared to income, level of education seems to have a greater effect on the use of diabetes technologies. Educational gradients consistently appear across our results, generally favouring high educated groups, but are particularly influential when technologies are new. Although results for level of income appear to be considerable, particularly in HUNT 1, suggesting trends similar to those found for education, income gradients are generally less consistent and prove to be in general less influential.

In addition to the inequalities presented in Table 4, results suggest that the frequency of using diabetes technologies also varies by SES, particularly for education. Available data from HUNT 2 and HUNT 3 (not available in HUNT 1) suggest that higher SES groups measure

blood glucose more regularly than low SES groups regardless of technology type, however, differences appear greater when innovative technologies are available. In HUNT 2, the low-education group on average measured blood glucose 4.3 times per week, the medium educated group 4.9 times per week, and the high-educated group 7.9 times per week, suggesting a strong educational gradient favouring those with higher education. These numbers were 3.9 and 6.7 for low and high-income groups respectively. In HUNT 3, however, the low-educated group on average measured blood glucose 5.1 times per week, the medium-educated group 4.8 times per week, and the high-educated group 5.6 times per week. These numbers were 5.3 and 4.7 for low- and high-income groups respectively.

Inequalities in the diffusion of diabetes technologies

The development of innovative technologies during the period HUNT 1 (1984–1986) to HUNT 2 (1995–1997) creates an opportunity for investigating socioeconomic inequalities in the diffusion of innovative technologies by following adoption patterns of a single cohort throughout this time period. Unfortunately, the relatively limited size of this cohort reporting the use of relevant technologies ($N \leq 190$) greatly restricted the power of our statistical analyses.

Bivariate analyses suggest that, during this period, the adoption of IIT was unequally distributed by SES, favouring individuals with high education and income. Here again we see an educational gradient, with the number of adopters increasing with education level. For GMT, bivariate analyses indicate that adoption is associated with higher income, but not education. As shown in Table 5, however, after controlling for age, gender, and duration of illness together in a longitudinal analysis, inequalities in adoption become statistically non-significant due to a low number of respondents.

Interestingly, however, we see much higher overall diffusion rates for GMT for both education and income (88.9% and 89.0% respectively) over IIT (64.7% for both income and education), suggesting the presence of mechanisms either promoting the diffusion of innovative GMT over this period, or acting as barriers to the diffusion of innovative IIT regardless of SES. Furthermore, average HbA1c levels in adopter (GMT = 9.1%, IIT = 9.0%), compared to non-adopter (GMT = 8.7%, IIT = 9.9%), groups seem to be unequally distributed (see Table S1). There is a clinically significant difference of nearly 1 per cent for IITs, favouring

Table 5 Odds ratio (OR) and 95 per cent confidence interval (95% CI) for adopting new glucose and insulin technologies by level of education and income in the HUNT 1 (1984–1986)–HUNT 2 (1995–1997) cohort. Nord-Trøndelag Health Study, Norway

	<i>New glucose technology</i>		<i>New insulin technology</i>	
	<i>OR</i>	<i>95% CI</i>	<i>OR</i>	<i>95% CI</i>
Education				
Low	1.00	Ref.	1.00	Ref.
Medium	1.53	(0.52–4.50)	1.11	(0.42–2.91)
High	0.80	(0.21–3.02)	4.02	(0.92–17.50)
Income				
Low	1.00	Ref.	1.00	Ref.
High	1.23	(0.21–7.19)	1.47	(0.44–4.93)

Note: All values in the table are adjusted for age, gender and length of illness.

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adopters of new technologies, but a reverse relationship for GMTs favouring non-adopters, although in this case not clinically significant.

Discussion

Our results suggest an overall increase in the prevalence of diabetes over the study period, accompanied by an overall decrease in HbA1c levels, regardless of SES or technology used. Results suggest a more active engagement by high SES groups, who often used technologies at a higher rate and frequency, demonstrating statistically significant educational inequalities in the use of innovative technologies that were not present for old technologies. These findings support results from a recent qualitative investigation by Øversveen (2020) into a similar topic. The diffusion of IITs demonstrated a similar trend over time, with an educational gradient favouring high SES. Diffusion rates for GMTs by SES, however, were scattered and absent of any similar trend. This may correspond with overall diffusion of GMTs during the study period, which was much higher than for IITs. In any case, longitudinal analyses for SES-based rates of adoption presented statistically nonsignificant results after controlling for age, gender, and duration of illness.

Social inequalities in diabetes management: understanding divergence in the present population

Our results, particularly for education, suggest that adoption and diffusion patterns witnessed in the cohorts from each HUNT survey independently as well as in the cohort followed over a 10-year period from HUNT 1 to HUNT 2 support the diffusion of innovations theory. SES-based inequalities in the adoption of innovative technologies included in this study appear to suggest that as education level increases so too do the odds and rates of adoption, particularly when technologies are new. Diffusion rates for IITs appear to support these results while diffusion rates for new GMTs seems to suggest less conclusive, somewhat contradictory results. However, overall adoption for this technology is much higher than overall adoption for IITs, suggesting that these GMTs have diffused more rapidly than insulin injection technologies and therefore achieved nearer to complete diffusion over the 10-year follow-up period. This may explain the absence of clear trends in the diffusion of GMTs. In any case, these results offer evidence in support of a typical diffusion of innovations pattern, with early adopter groups generally consisting of individuals of higher SES and later adopters generally of lower SES (Rogers 2003).

The larger inequalities witnessed in the adoption and diffusion of innovative diabetes technologies is possibly due to higher SES patients more often using specialist services and/or being recommended for intense treatment regimens. Previous research has shown that clinicians often consider high SES patients to be more motivated and more capable of effectively utilising more intense treatment regimens that utilise innovative technologies (Lutfey and Freese 2005, Naranjo *et al.* 2016, Scott *et al.* 2017). This type of institutional agency, where treatment recommendations vary between high and low SES patients based on assessed capabilities, may result in these technologies being prescribed and recommended more often to higher SES patients (Brown *et al.* 2004, Lutfey and Freese 2005, Naranjo *et al.* 2016, Ricci-Cabello *et al.* 2010). Our results suggest that this effect may persist to a degree even in single-payer universal healthcare systems.

Although the institutional agency argument may offer an explanation for the unequal diffusion of technologies between high and low educated user groups, it does not offer a reasonable explanation for the higher total diffusion rates of GMT compared to IIT. Goldman and

Lakdawalla (2005) have previously concluded that innovations that simplify treatment and care act to reduce health disparities and it is possible that the innovation in glucose measurement simplifies diabetes treatment more so than the innovation in insulin injection. An alternative explanation, however, may lie in manufacturers of glucose measurement devices being sometimes willing to sell these devices at very low cost (or even free of charge), in the hope that patients will then continue to pay for the costly strips needed to use the devices (Clarke and Foster 2012, Lutfey and Freese 2005). State-led directives may reinforce this high rate of diffusion as the cost of obtaining and using digital glucose measurement devices were, during this period, covered by state insurance programmes (Midthjell *et al.* 1988). However, although patients were able to receive their first insulin pen free of charge from producers, state insurance programmes at the time did not cover the costs of continued use (Midthjell *et al.* 1988).

In any case, total diffusion rates may mask inequalities in use patterns (such as frequency), as demonstrated by high-educated patients in HUNT 2 on average measuring blood glucose nearly twice as often per week as low educated patients. This suggests that patients of lower SES may have received and used these devices for a period of time, but to a greater degree discontinued or reduced usage of the device, a finding supported by earlier research identifying relevant psychological and economic barriers (Lutfey and Freese 2005, Naranjo *et al.* 2016) and also further supported by the diffusion of innovations theory (Rogers 2003).

Although our results demonstrate that high SES groups are in some cases significantly more likely than low SES groups to use innovative technologies, it is less clear that these technological innovations are effectively used to improve disease management. If one accepts variance in HbA1c levels of 0.5 per cent as clinically significant, average HbA1c levels in this study do not show a clear advantage in favour of high SES groups or users of innovative technologies (Lenters-Westra *et al.* 2014).

The (re)production of social inequalities in health: innovative technologies as a material and symbolic resource

While our results do not offer conclusive evidence for causally explaining inequalities in health outcomes as a consequence of the unequal adoption and diffusion of medical technology, they do support the premise that innovative technology may be an important mechanism through which inequalities are (re)produced. The early adoption of health innovations may afford users with specific benefits, that can accumulate over extended periods, but which do not necessarily present as traditional markers of illness (Chang and Lauderdale 2009, Link *et al.* 1998, Rogers 2003). An innovative insulin pen, for example does not necessarily need to exhibit a significant impact on HbA1c levels for it to be a symbolic representation of the ideal patient or ideal user, which in the eyes of a clinician or other health-related personnel embodies a more worthwhile investment in additional resource allocation (Brown *et al.* 2004, Lutfey and Freese 2005, Naranjo *et al.* 2016). The clinician, in this case, is not just a gatekeeper to additional services, but also an agent of change, facilitating the flow of innovative technologies to users and providing a link between clients and a resource system (Rogers 2003).

Prior research has established that these ‘change agents’ communicate best and most often with individuals of similar (i.e. high) SES (Rogers 2003), a finding supported by the current research suggesting that high SES patients often accrue additional advantage from improved relationships with providers of care (Brown *et al.* 2004, Lutfey and Freese 2005). Likewise, evidence suggests that technological innovations symbolise a certain level of resource procurement in society that can then be exploited to a larger degree by individuals of high SES, reinforcing class distinctions and therefore a reproduction in inequalities in class-based power (Gabe and Monaghan 2013, Grenfell 2014, Veenstra 2017). In short, patients who master

technological resources (regardless of the specific technology's effect on managing a particular illness) are often rewarded with an increased share of relevant valuable resources, further reinforcing the positive distinguishment of proficient users over less-proficient or non-users (Øversveen 2020). Furthermore, these subtle forms of symbolic inequalities fail to account for tangible inequalities in relevant quality of life associated with the proficient adoption and use of modern technologies, which are often designed to not just improve the effectiveness of managing illness but also reduce the suffering, discomfort or burden often associated with managing an illness (Lupton 2012). The high SES user, for example with the competence, knowledge, time and financial resources to ensure acquisition, and effective use, of a state-of-the-art GMT hooked up to a modern insulin pump, delivering real-time data to a computer-based analysis software program, is not only going to be afforded with a less intrusive and more stable and predictable quality of life, when compared with a low SES patient who is only able to, based on available capital (in all its forms), acquire rudimentary syringes and a basic digital glucose monitor for managing their diabetes. This actively engaged, high SES patient is also likely to, for reasons associated with their display of masterfully managing both their illness and the innovative technologies largely symbolising representations of modern medicine (i.e. the ideal 'empowered' patient), be 'rewarded' (albeit largely unconsciously, as a result of both internal and external cultural and systemic pressures) with higher quality clinical interactions and a greater level of effective institutional resource allocation (Øversveen 2020).

As our results therefore suggest, a diffusion of innovations perspective focused solely on rates of adoption and diffusion has the potential to conceal SES-based inequalities in the various ways in which these technologies are used, both consciously and unconsciously, to accrue advantages by individuals at various levels of the social strata. The potential symbolic (i.e. hidden representational) value of technological innovations in health combined with durable inequalities in the adoption, diffusion and individual exploitation (i.e. use) of these resources, offers an argument for these technological innovations as a potential mechanism for (re)asserting or maintaining status-based positions of power and naturally (re)producing fundamental inequality. However, it is clear that more research is needed to further investigate the relevance and strength of these relationships and it is our hope that the preliminary work in this paper can contribute to further exploring both theoretical and empirical developments.

Strengths and limitations

The main strength of the current analysis is its presentation of a preliminary model for further investigation of the role technological innovations in health play in the persistence of health-related social inequalities. In so doing, this study also offers novel insights into the various mechanisms linking technological innovations with social inequalities in health, using diabetes as a case.

However, relevant limitations in this analysis include a comparatively small sample size, resulting in low statistical power in the longitudinal analyses, relatively coarse groupings for SES, and an inability to run analyses differentiating between type 1 and type 2 diabetes (type 1 is, for example, much more dependent on the use of technology, however, is much less common in the sample, so much so that the total number of individuals with type 1 diabetes alone is far too small for powering statistical analyses). Furthermore, mechanisms in selection processes may influence treatment options, where patients with more severe diabetes receive earlier recommendations for new technologies regardless of SES. Lower SES individuals, often suffering from more severe diabetes, also tend to be underrepresented in the survey material (Langhammer *et al.* 2012). Moreover, the current dataset did not allow for separating between non-adopters who would benefit from technological aids (of interest in this study) and non-adopters who do not have a need for technological aids (of little relevance for this study), therefore non-

adopter (or non-user) categories likely include an artificially high representation of high-SES individuals (who are able to control often less severe forms of diabetes with lifestyle changes). Furthermore, due to our study using market availability as a way of determining the effective age of technologies, some devices that had been available for some time, but were particularly advanced (such as insulin pumps) have been categorised, alongside less advanced devices (such as syringe), as old technologies. Therefore, future studies may consider, instead, using total diffusion rates to determine the effective age of technologies (i.e. high diffusion rate = 'old' technology; low diffusion rate = 'new' technology), although this method does present its own challenges. As a result of the above limitations, it is important to note that SES-based inequalities in this study are likely to be under, rather than over, estimated.

Of further significance is a lack of information on the adoption of specific innovations within technological categories over time. Although types of technologies in our analysis are in some cases considered old technologies, new types of technologies are constantly being developed within these overarching categories that create a possibility for multiple adopter groups within the same technology type (e.g. 'old-style' vs. 'new-style' insulin pumps). Similarly, the specific technologies analysed in this study are all relatively old, even if modern devices exist within the general technological categories addressed in this study. Furthermore, the current dataset, unfortunately, did not allow consideration for variations in the duration of technology use. In some cases, reported users may have only used these technologies for short periods or discontinued use altogether.

The importance of this study, however, lies in its ability to use relatively old technologies (that have had time to diffuse) as a case for understanding adoption and diffusion patterns as they relate to SES-based inequalities, contributing to an understanding of the ways in which current and future innovative technologies are potentially following similar, not yet recognisable, patterns. Furthermore, the preliminary analytical model used in this study offers an important methodological first step for conducting similar analyses on contemporary technologies. Many of the limitations in this study, however, could be accounted for with the use of a more suitable dataset, which we are currently unaware exists.

Conclusion

Although clear limitations exist in our study, and we consider much of this study to be preliminary and experimental in nature, our results suggest that SES-based variations in access and use of innovative technologies in health may act as a mechanism through which inequalities are reproduced, even in a country with tax-financed public health services with universal coverage. Our findings suggest that high SES groups tend to be earlier adopters, and more active users, of technological innovations in health. Furthermore, results from this study indicate that the rate of diffusion of these innovations influences the persistence of inequalities and has the potential to conceal SES-based variations in the use of these technologies. Evidence for a direct relationship between these inequalities and inequalities in diabetes-related health outcomes such as HbA1c levels is, however, somewhat surprisingly weak. Our data, however, does not address other important health-related outcomes, such as reductions in pain or stress, subjective improvements in effective use of time, or a simplified daily disease-management regimen associated with the use of new technology.

Although we would expect to see larger effects of SES-based inequalities in access and use of health improving technologies in countries with weaker welfare state regimes, future analyses would need to include cross-country comparisons, as well as address limitations associated with selection and analysis processes, to investigate whether this is true. Our results, however,

suggest that although it is possible that income-based inequalities are moderated by strong welfare programmes, other significant SES-based inequalities in the access and use of health technologies, such as education-based inequalities, can persist even in a single payer system where these technologies are fully or partially covered by state-sponsored insurance programmes.

We argue that these inequalities may be partially explained by the ability of innovative technologies in health to act as a form of symbolic capital that reinforces the social hierarchy, therefore offering greater benefits to high SES groups who are in a better position to access and exploit additional resources used to promote health or manage illness. Innovative technologies in health may therefore be a resource allowing for the expression of the relative value of higher social position. This study will hopefully inform similar future analyses, which are necessary to provide further investigation into relevant, and important, social mechanisms that may provide insight into the persistence of growing social inequalities, including those in health.

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Author Contribution

Daniel Weiss: Conceptualization (lead); data curation (equal); formal analysis (equal); investigation (lead); methodology (equal); writing-original draft (lead); writing-review & editing (lead). **Erik R. Sund:** Conceptualization (supporting); data curation (equal); formal analysis (equal); investigation (supporting); methodology (equal); supervision (supporting); writing-original draft (supporting); writing-review & editing (supporting). **Jeremy Freese:** Conceptualization (supporting); formal analysis (equal); investigation (supporting); methodology (equal); supervision (supporting); writing-original draft (supporting); writing-review & editing (supporting). **Steinar Krokstad:** Conceptualization (supporting); data curation (equal); formal analysis (equal); funding acquisition (lead); investigation (supporting); methodology (equal); project administration (lead); resources (lead); supervision (lead); writing-original draft (supporting); writing-review & editing (supporting).

Conflict of interest

None declared.

Supporting information

Additional Supporting Information may be found in the online version of this article:

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Table S1. Unadjusted values for number of adopters/non-adopters of diabetes technologies by socioeconomic status, with corresponding mean HbA1c values, for the cohort from HUNT 1 (1984–1986)–HUNT 2 (1995–1997) in the Nord-Trøndelag Health Study (HUNT), Norway.

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RESEARCH ARTICLE

Open Access

Round hole, square peg: a discourse analysis of social inequalities and the political legitimization of health technology in Norway

Daniel Weiss^{1,2} **Abstract**

Background: As research increasingly investigates the impacts of technological innovations in health on social inequalities, political discourse often promotes development and adoption, limiting an understanding of unintended consequences. This study aimed to investigate national public health policy discourse focusing on innovative health technology and social inequalities, from a Norwegian context.

Methods: The analysis relies on a perspective inspired by critical discourse analysis using central State documents typically influential in the lawmaking procedure.

Results: The results and discussion focus on three major discourse strands: 1) 'technologies discourse' (types of technologies), 2) 'responsibility discourse' (who has responsibility for health and technology), 3) 'legitimization discourse' (how technologies are legitimized).

Conclusions: Results suggest that despite an overt political imperative for reducing social inequalities, the Norwegian national discourse gives little attention to the potential for these innovations to unintentionally (re)produce social inequalities. Instead, it is characterized by neoliberal undertones, individualizing and commercializing public health and promoting pro-innovation ideology.

Keywords: Social inequality, Health, Technology, Innovation, Discourse analysis, Norway

Background**Introduction**

We have long understood the powerful potential of innovative technologies when developed and adopted by society's individuals and institutions. These resources can afford often inconceivable benefits and are frequently necessary to elevate or sustain positions in the prevailing social or political hierarchy. In contrast, the decision to ignore or abandon the development, adoption or implementation of innovative technologies is also often a decision to relinquish social, economic, cultural, or military superiority and power.

Political discourse and arguments of social progress and superiority have contributed to a persistent and widespread positive bias for the development and adoption of technological innovations in society. This attitude has dominated the public policy sector, where there has been a push to reform *innovation* from a historically negatively loaded term to a positive one [1]. As a result, innovation, particularly in relation to technology, has largely become an undisputed practice [1–3]. This perspective is naturally spilling over to policies related to health technology, where the often argued 'neutrality' of technological innovation can be questioned [3, 4].

Although technological innovations have proven, in many cases, to be extremely useful and effective, uncritical development and adoption of these technologies opens for a myriad of unanticipated and often undesirable consequences that undermines their aggregate

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social value. Recent research has begun to investigate and document these effects, presenting a complex picture of health technologies [2, 3, 5–8]. These consequences are increasingly being recognized as mechanisms that have the potential to (re) produce social inequalities in health [4, 9–12]. It is increasingly clear that technological innovations produce winners and losers, as is apparent with innovative technologies entering the labor market but also those entering the health sector. Attention for these associations comes at a time when social and political awareness is increasing for understanding the mechanisms that are leading to a modern growth in national and international social inequalities, including those in health [13–17].

Therefore, understanding how current political ideologies are addressing the association of an increasingly technology-affected health sector with growing inequalities in health becomes relevant for understanding the social value and broad impact of these innovations [8]. Analyzing political discourse has been highlighted as an effective method of exposing political ideology while also investigating the ways through which official use of text (re) produce dominance, social hierarchies and inequalities [18–20].

Norwegian context

The Norwegian case is interesting for a number of reasons. Firstly, Norwegian public health policy is bound by law to promote health and reduce social inequalities. The Norwegian Public Health law of 2012 explicitly states, 'The goal of this law is to contribute to a social development that promotes public health, including reducing social health inequalities' [21]. Secondly, the Norwegian commitment to be an international leader in the development, adoption and implementation of health technologies is significant, structurally integrating this work into government agencies and policies. The Norwegian government, as of 2016, has a Directorate for e-Health with a wider mandate for organizing, implementing and guiding policies and technologies in e-Health and information and communication technologies (ICT) in the health and care sector. This directorate is a product of almost 30 years of political commitment in this area, starting with the creation of the Norwegian Competence center for information technologies in the health and social sector (KITH) in 1990. These efforts have in part contributed to high overall rates of household internet access across income categories (93% for household income between 0 and 299,000 Norwegian kroner compared to 99% for households with an income over 900,000 Norwegian kroner) [22]. However, age and gender inequalities persist in the use of internet-based technologies, where, for example, over 66% of men age 16–34 years have used the internet to search for health-related

information during the previous 3 months compared to under 40% for those aged 65–79. For women this gap is even larger, with over 86% between the ages of 16–34 and only 51% between the ages of 65–79 [23]. Furthermore, some research has suggested that there is large variance in the types of users of internet-based activities and that age and gender often determine significant variations in use patterns [24]. Furthermore, non-users generally have lower levels of education and are often unemployed [25]. Although these numbers far from fully represent the complexity of socially constructed inequalities and digital technologies, one could argue that focusing merely on remedying these inequalities is unjustified as they may be shaped by differing views on the use, and importance, of the internet and digital tools in society by various social groups that do not necessarily correspond with a single standard of social conformity. These inequalities, however, (particularly when coupled with access to broad social benefits being dependent on digital or internet-based tools) may contribute to reproducing other fundamental, and inherently unfair, social inequalities, such as inequalities in health. In this regard, Norway has repeatedly been referenced in relation to an elusive 'Nordic paradox', where one would expect low levels of inequalities in health due to generous welfare policies and a focus on promoting social equality, but where these inequalities instead remain relatively large and persistent [16, 26, 27].

Interest and aims

Based on the information above, the broad interest of this study is to investigate the national public health policy discourse with specific focus on innovative health technology and social inequalities. More specifically, the central questions under investigation in this study are the following:

1. How is responsibility in the discourse assigned for the development, adoption, and implementation of innovative technologies in health and how is this discourse entangled with a more general discourse of responsibility for health?
2. How are innovative health technologies legitimized in the discourse and how is this discourse entangled with a social inequalities in health discourse?

Methods

Documents

The documents in this study focus solely on political discourse (i.e. a single discourse plane). The analysis includes a total of 33 central strategic planning documents – such as white papers – and government reports from various government departments and agencies as well as specific plan and strategy documents from the

Norwegian Directorate for e-Health (see Appendix 1). All these documents are typically influential in the law-making procedure [19, 28]. Included documents addressed health technology in a public health policy context.

Data collection

Similar to methods of grounded theory, the systematic collection of documents analyzed in this study was not a distinct, isolated stage but rather a continuous and recurring process throughout the study period [19]. Recommendations for central documents by way of consultation with representatives from the Norwegian Health Directorate and the Norwegian Directorate for e-Health were followed by a hand search of government websites and historical archives. Following the collection of a sample of central documents, a snowball method was used to collect additional documents of relevance that were referenced in the originals (see Appendix 1).

Only documents after 1997 were included in the analysis as this date has been specifically referenced in several documents as the year in which an official government agenda surrounding health technologies began [29, 30]. Some documents were not analyzed and coded in their entirety as some broad public health documents included large sections of content irrelevant for the aims of this study (i.e. unrelated to *both* health and technology; see Appendix 1 for more details).

Analysis

The analysis relies on a perspective grounded in a critical research approach to analyzing political discourse, an area relevant for public health concerns [31]. Critical research is often characterized by a focus on social inequalities, power relations, politics, and issues related to agency and empowerment that “shifts research away from the production of knowledge for knowledge’s sake and edges or nudges it towards a more transformative vision of social justice” [32, 33]. This analysis is therefore inspired by various methods of Critical Discourse Analysis (CDA), a well-developed field of study also focused on research methods that critically analyze how hegemony and inequality are (re) produced and legitimized in text and talk [18, 19, 28]. Although a single, distinct set of methodological criteria for CDA are rarely referenced (and in fact typically resisted in the literature), this study follows a structure grounded in Jäger and Maier’s methodological outline [19]. Where the methodological approach in this study departs from traditional CDA is the absence of detailed linguistic operationalization of discourse fragments, often focused on analyzing structural aspects of the text at the level of the sentence or word, such as lexical style, word order, and syntactic and propositional structures. Instead, this study focuses on a

thematic analysis of the material, however drawing inspiration from CDA’s theoretical and methodological approach to critically identifying contradictions in dominant strands of discourse that may reproduce or legitimize existing inequalities in power. By drawing inspiration from CDA, and applying Jäger and Maier’s general structural analysis of discourse strands, this analysis has been able to identify and disentangle broad dominant strands of political discourse that represent institutionalized forms of, what Bourdieu would refer to as, symbolic violence (namely, the misrepresentation of unconscious reinforcement of existing imbalances in power in society as legitimate forms of social normalization) [19, 34].

All coding and analysis were performed using Nvivo. Coding focused on three major themes: 1) reference to specific technologies and their technical definitions; 2) responsibility for technology adoption and diffusion in a health context; and 3) general attitudes towards technology, with an ancillary perspective grounded in social inequalities. The material included in this analysis (see Appendix 1 for more details) was first coded using a broad range of codes representing four general thematic areas of interests: 1) Understanding of technology and innovation, 2) Understanding of public health and social stratification, 3) Reference to action and policy, and 4) General (see Appendix 2 for a full list of codes used in the analysis). The identification of relevant codes followed a combination of inductive and deductive processes, where some central codes were identified a priori, in part in relation to the findings from a systematic review on a similar topic [9]. Additional codes were then identified during initial examination of central documents first collected on recommendation by relevant authorities. Throughout the snowball process, additional codes were identified and/or incorporated into existing codes if new documents presented relevant information that was not present in previous documents, but which added to new perspectives relevant for the aims of this analysis or one or more of the thematic areas of interest. In addition, summary notes were written for each document. Following this initial coding, all coded material was recoded with a focus on organizing the material into the following discourse strands: types of technologies dominating the discourse (resulted in subcodes ‘biotech’, ‘e-health and IT’, ‘electronic journals’, ‘welfare technologies’, and ‘others’); the assignment of responsibility at various societal levels (resulting in subcodes ‘health care institutions’, ‘multisectoral, general’, ‘private, general’, ‘private, individual’, ‘private, industry’, ‘public, general’, ‘state, national’, ‘state, regional’, ‘state, local’); and, attitudes towards technology, or political ideology as it relates to health technology (resulting in subcodes ‘pro-innovation’, ‘legitimization, commercialization’, ‘legitimization, empowerment’). The subcodes represent the

emergence of dominant themes within each discourse strand. A conceptual mapping exercise was used in order to further reduce the quantity of data (using both document notes and the remaining coded material), identify the importance and weight of existing discursive themes, identify and organize discursive entanglements, and organize dominant themes diachronically (Appendix 3).

Results

Technology types & definitions: themes surrounding the discussion of specific technologies

Discussions of technologies are dominated by a focus on e-Health and ICT technologies, electronic patient journals, welfare technologies, and biotechnologies. Although there is often significant overlap between these groupings, the technologies within each of these categories are often discussed in isolation, with distinct definitions and objectives.

E-health & ICT

E-health technologies dominate in the early years (1997–2005). During these years, there is a heavy focus on the use of the internet (more generally as a platform for sharing information using online portals, databases and websites) and internet-based communication technologies (email, telemedicine, online booking). Tools to access and use the internet (mobile phones, computers, tablets) are naturally a large part of this discourse from early on but it is not until after 2010 that we begin to see technologies like modern applications for smart phones and tablets enter the discourse (m-Health), strengthening in more recent years. The years after 2010 also mark the rise of monitoring and surveillance technologies (portable, wearable or home-based sensors and measurement devices). The post-2013 years also see big data, cloud-computing, robotics, and the internet of things enter the general discourse. Throughout the study period, e-Health technologies are discussed in relation to health services settings, however discourse centered around technologies become increasingly focused on consumer, (digital) self-service, and home-based technologies, particularly in the years after 2013.

Electronic patient journals

Although electronic patient journals (EPJ's) are themselves an e-Health technology, they are often prioritized as a distinct technological innovation. EPJ's begin permeating the general discourse in the years following 2000. They quickly become a central and persistent thread. Their dominant position is strengthened in the years following 2008, with a focus on implementing a streamlined national EPJ system (called '*one inhabitant – one journal*', outlined in the white paper with the same name in 2012). EPJ development is, throughout the

study period, discussed in conjunction with, and dependent on, an internet-based platform used to offer various individualized services.

Welfare technology

Welfare technologies, as a distinct group of technologies, enter the general discourse in the years following 2010 (however some of the individual technologies later classified as welfare technologies appear in the discourse before this). Not coincidentally, this dominant position in the discourse coincides with the term 'welfare technology' being more concretely defined and its use becoming more universally recognized (politically, technically, etc.) around the year 2010/11. Although we see a strong overlap with e-Health, welfare technology after 2010 is often addressed as a distinct technological innovation, divided into four categories: 1) Safety and security technologies (such as alarm systems that monitor various conditions of the individual or the home); 2) 'Compensation and wellness' technologies (technologies that compensate for reduced physical or mental functioning such as robotics, smart home technologies, home-based physical activity and rehabilitation technologies, and automatic scheduling technologies such as electronic medication reminders); 3) Technologies for social contact (such as video communication, social media, the internet, and robotics); 4) Treatment technologies (such as patient journals, technologies for information and communication sharing with health personnel, and sensor technologies that monitor, record and send health-related information). Discussions of specific technologies are inspired largely by technologies that act as logistical aids, sensors for 24-h surveillance and monitoring of both the home and the patient/individual (with GPS capability for example), remote home-based communication, and home-based treatment, analysis and care.

Biotechnologies

Although biotechnologies are mentioned in documents before 2010 (gene technologies, systems biology, designer medications, and biological implants such as sensors and micro/nanotechnologies), biotechnology does not become a dominant part of the general discourse until the years following 2010. Focus is given to molecular and gene-based technologies (gene sequencing and testing, diagnostics and therapies) and novel prescription medications (including advanced therapy medicinal products), sometimes mentioning stem cell, biological implant and nanotechnologies. The gene-based technologies also inspire discussion of the value of personalized medicine as an innovation (witnessed in part in a 2011 document detailing the national strategy for biotechnology).

Other technologies

Other technologies enter the general discourse from time to time but tend to be much less influential when compared to those listed above. Technologies of note, however, include innovations to more traditionally institutionalized diagnostic and treatment technologies (such as mobile x-ray and ultrasound devices, MR, CT, PET, image guided surgery).

Technology, health and the 'responsibility discourse'

Disentangling discourse strands relevant to the assigning of responsibility for public health (broadly defined) and responsibility for health technologies (from development to adoption) resulted in the emergence of the following trends in what we are calling the 'responsibility discourse': 1) consistent general State oversight and promotion; 2) a transferring of increased responsibility to the local level; and 3) a continued focus on strengthening public/private partnerships.

The state

While the State assumes central responsibility for ensuring equal services and population-wide public health throughout the study period, the responsibility discourse is increasingly framed within the confines of empowering the individual. Here, focus is on the State's responsibility to ensure equal opportunity while challenging the individual to assume greater responsibility for personal health.

'It is about finding the right balance between the individual's responsibility for one's own life and the authorities' responsibility for creating the most equal conditions possible.' [35]

For health technologies, the State assumes responsibility for setting national standards as well as coordinating and constructing a national infrastructure for implementation, particularly for e-health/ICT. The State accomplishes this through its departments, directorates and organizations for research and innovation. After 2012, focus increased on the State's role as a major purchaser of health technologies and an agent for pro-innovation regulation. 'The Government has an objective of increasing the degree of innovation in the health, care and welfare services, and for the public sector to be a driving force for, and active user of innovation.' [36]

This is to be accomplished primarily through a national center for health-IT and welfare technologies – for which the national Health Directorate is assigned increased responsibility. In 2016 the e-Health Directorate is established and given responsibility for strengthening the State's role in e-Health management, financing, delivery and organization at the national level. Similarly, a

national center for e-Health research is created to 'collect, produce and disseminate knowledge needed by authorities to develop a knowledge-based e-Health policy' [37]. This primarily to increase the pace of development and implementation of technology in this sector. 'National governance ... management, financing, delivery, organization and implementation of e-Health shall contribute to realizing e-Health in a faster and more cost-effective manner.' [38]

Local level actors

From the mid-2000's a general focus on transferring responsibility to the municipality level intensifies. This transfer of responsibility to local state actors is further strengthened with a legal precedence anchored in a documented national coordination reform for public health [39] released in 2009 and which went into effect in 2012 (the same year as the new national public health law).

'... the projected growth in needs within a collective health service must as far as possible find solutions in the municipalities.' [39]

'The municipalities themselves have responsibility to exploit opportunities that lie in new technology ...' [30]

Although the State continued to assume responsibility for national coordination, municipalities are increasingly expected to assume responsibility for making local-level decisions concerning the implementation of public health services and the availability of health technologies. It is argued that through decentralized decision-making at the municipality level, health promotion and prevention efforts can be more effective, and available technologies can more effectively meet local needs. This includes municipalities strengthening their role as the State's purchaser of health technologies and promoter of public sector innovation, but also increasing private sector business development at the local level. 'The municipalities have a central role in public health work across different sectors, in primary services and in business development.' [40]

Focus on private individuals also increases, particularly as interest in transferring responsibility to the local level intensifies. From the beginning of the study period, the discourse in general stresses the importance of individual choice and responsibility, but continues to mention the importance of structural and systemic environmental characteristics.

'Individuals and communities have responsibility for public health work, but the population's health is not

least a result of developments and political choices beyond the reach of the individual.' [41]

A responsibility discourse focused on individuals strengthens throughout the study period, with the emergence of an 'empowerment discourse' gaining strength in the mid 2000's, complimenting the 'responsibility discourse' and focusing attention on increased user involvement. Discussions of user involvement center on a transfer of greater freedom and control to the individual, improving service delivery and more effectively meeting the needs of the user. A further, detailed explanation of who these users are is however missing from the discourse.

In the wake of the 2009 national coordination reform, this empowerment discourse again strengthens into an *expectation* of user involvement in both the delivery of health services and the formation of public health efforts, but also in the adoption of health technologies. Although user involvement is presented as a means of empowering the individual, the empowerment discourse also provides legitimacy for the transfer of an increased amount of responsibility to private individuals.

'Measures for improving patients' and users' ability to care for their own health contributes to a better quality of life for the individual, and to the development of a more sustainable health and care service ... It is also crucial that patients and users are encouraged to set their own goals for health and health behavior, and are not just passive recipients of others' advice and recommendations.' [42]

'Although the public sector accounts for much of the health and care sector procurement, we expect users and their relatives to become an increasingly important customer group that will demand technology, such as tablets and digital measuring devices.' [43]

As these 'responsibility' and 'empowerment' discourses evolve, health technologies are themselves increasingly seen as an active resource for supporting and promoting the effective transfer of responsibility. 'Technology will challenge people to take responsibility, both for welfare programs, their own life and in relationships to other people in daily life.' [44]

'New technology gives patients more responsibility and control.' [45]

Home-based health technologies are seen as central to this objective. These technologies provide an opportunity for physically relocating the point of services, and

therefore responsibility, to settings controlled by individuals and, to a lesser extent, municipalities. The empowerment discourse contributes to emphasizing the importance of innovative health technology and further legitimizing its development, adoption and use. 'The monitoring of one's own health, home-based solutions and technology that can help people remain at home for as long as possible, will be important with respect to sustainable development, disease prevention, improved quality of life and active ageing.' [36]

Public-private partnerships

Focus on strengthening public-private partnerships, by investing in innovative health technologies, for delivering health services and general public health is central to the responsibility discourse throughout the entire study period.

'The Norwegian health and care sector needs an improved interaction with the business sector to achieve its goals.' [40]

Public-private partnerships are justified as a means of improving health services throughout the sector, but are also presented as a means of commercializing these technologies, by strengthening and supporting a health technologies industry, and therefore promoting national value creation. The research community is presented as a central State agent for strengthening this partnership, by using public funds and research grants to support private sector technology development and transfer. 'Today the industry is small, but it can become a growth industry with global potential... A business community with strong and innovative companies that embraces innovations from the research community is a prerequisite for good health and welfare services in the future.' [40]

Municipalities are again challenged to take increased responsibility for health technologies by partnering with industry to develop and implement effective technologies to innovate and streamline service delivery (i.e. an 'innovative public purchaser'). Local and regional health-care institutions are expected to be actively involved in these efforts, to test and implement technologies. Municipalities are also expected to involve individual users in development and implementation processes. Focus on involving these partners, particularly individual users, once again connects the responsibility discourse to the empowerment discourse, with a stated goal of better integrating user needs. However, a discussion around whether strengthening public private partnerships is an effective political strategy for achieving this goal seems

mostly assumed and expected. 'Municipalities have also had close cooperation with suppliers to improve products so that they better meet user and service needs.' [46]

'The public sector constitutes an important domestic market for Norwegian industry. Purchasing through innovative acquisitions ... is an important tool.' [40]

Focus on building and strengthening public-private partnerships intensifies in the post-2013 years.

Technology, health and the 'legitimization discourse'

Throughout the study period, the discourse is highly partial to positively representing health technologies. Although some of the challenges associated with these technologies are at times discussed in detail, focuses tends to be on technical and security issues, which are seen as barriers to the development and implementation of these technologies. The technologies themselves are rarely questioned and broader social concerns are largely ignored. Although questions of social inequality are sometimes referenced, attention is mostly on regional inequalities, based on variations in municipal priority-setting and financial resources. Issues of social inequalities are rarely addressed, and technologies are often seen as likely of reducing social inequalities as they are a mechanism for increasing them. This positive representation of health technologies leads to a discourse increasingly focused on legitimizing the role of health technologies (i.e. the legitimization discourse).

Pro-innovation (technology) bias

A pro-innovation bias dominates throughout. Technologies are presented as a necessary resource for the proper functioning and effectiveness of health and welfare services. Promoting the adoption and diffusion of these technologies is therefore explicit in the discourse.

'eHealth is the single-most important revolution in healthcare since the advent of modern medicines, vaccines, or even public health measures like sanitation and clean water.' [30]

'Medical technology, welfare technology and new innovative solutions must be developed and implemented.' [47]

This legitimization discourse tends to emphasize the pressing nature of rapidly promoting adoption and diffusion of these innovations and stress the inevitability of a technology-based public health service. Furthermore, rather than discussing broader potential social consequences of these innovations, the consequences of *not*

adopting are often insinuated to strengthen the power of a pro-innovation and pro-technology ideology.

'We are facing a rapid development in medical technology and welfare technology.' [47]

'It is necessary to focus on innovation, knowledge and technology in order to meet the challenges in the sector, as well as to facilitate safe, high-quality services, renewal and industrial development.' [36]

This pro-innovation ideology continuously emphasizes the benefits of these technologies. These benefits tend to be grounded in prevailing social values, such as government efficiency, individual freedom, quality and safety, and economic growth, adding strength to this pro-innovation ideology. Whether these benefits are based on reliable and representative data for specific technologies or a general faith in innovative technologies is sometimes unclear.

'Demands for action, belief in progress and expectations of increased prosperity and welfare are among the main driving forces behind the demand for new technology.' [48]

Legitimizing health technology

Discourse strands focused on public empowerment and market potential are used to further legitimize the development, adoption and implementation of health technologies, defending a general pro-innovation ideology.

As a focus on increased user involvement and responsibility evolves, so too does the empowering capabilities of innovative health technologies – connecting the legitimization and empowerment discourses. Health technologies are presented as effective tools for promoting empowering social processes such as democratic decision-making, the personalization of services, and an increase in individual freedom, control and autonomy. The legitimization discourse however is ambiguous in discussing whether these technologies have in fact demonstrated these effects or whether these effects are simply expected and desired. Additionally, whether unanticipated and undesirable consequences could potentially undermine or outweigh the positive capabilities of these technologies is left completely unaddressed. In general, it is assumed that the empowering effect of these technologies will consequently improve quality of life for adopters and users.

'Increased use of welfare technology will give new generations of older people and other user groups

more choice, increased security and independence and greater opportunities for participation in social life.' [44]

'The use of technological facilities for localization, such as the use of GPS, can help to provide greater freedom for patients/users in that they can go out without a follower, which will be important and increase the quality of life for many.' [49]

The legitimization discourse leans on a general assumption that the public desires and demands technological innovation and is generally familiar with and satisfied with the general development and direction of health technologies in society. These statements however rarely contain reference to information that may in fact support these claims.

'At the same time, users, patients and society have expectations that ICT in the healthcare system will develop in line with the development they know from other areas of society.' [50]

Furthermore, a general presupposition that technological innovation will invariably create value in society is persistently used to legitimize the development, adoption and diffusion of technological innovations. The research community is expected to be an active stakeholder in these efforts, explicitly contributing to the development of products, resources and research results that can be patented and commercialized. By the late 2000's the market potential of technological innovations in the health sector is strongly embedded throughout the general discourse. The ability to innovate is explicitly linked to an ability to create value. There is a general representation that innovation is, and always has been, the foundation of the welfare state.

'Innovation has always been a central source of value creation and for the development of the welfare society.' [51]

'The Government will support the development of health-friendly business as a political priority area for innovation and industry.' [52]

The State's role is therefore to support private sector innovation with the justification that innovative health technologies are a mechanism for driving both large national economic returns as well as improving public health services more generally. Innovation, particularly technological innovation, is presented as nothing other than a win-win for all sectors of society.

'The health industry can be described as an industry with double gains. The advances that are made

contribute to welfare and health while simultaneously creating value and jobs.' [45]

Whether this is truly the case is rarely investigated, or in any case presented, in a comprehensive way. Moreover, the legitimization discourse suggests a dominant ideological positioning of innovation, particularly technological innovation, as a means of promoting a particularly economic international competitive advantage. 'Stronger industrial development in the health and care sector ... will also ensure improved conditions for the Norwegian private sector in terms of technology development and service innovation in a broad and growing global market.' [36]

The technological innovation paradigm therefore becomes a political 'necessity' that must be exploited to a much larger degree. Attention is given to the significance of negative economic (as well as social) consequences of slow or no technological innovation, while simultaneously highlighting the endless benefits of increased innovation. After 2013, particular attention is given to internationalization and the development of an export market for these innovations.

Discussion

Throughout the study period, a number of trends emerge. E-health and welfare technologies dominate as broad (but sometimes overlapping) categories of prioritized health technologies, with specific focus on innovative technologies that improve capabilities for monitoring, surveillance and self-care. Responsibility for applied development, adoption and diffusion of these technologies is dominated by a focus on the role of municipalities and individual users. The State however retains ultimate control over the general positioning of these technologies, with a growing interest in forming partnerships with, and supporting, the private sector. Moreover, the innovative potential of these technologies is presented as socioeconomically positive and efforts to legitimize these technologies focus on individual empowerment and the promotion of national wealth and economic competitiveness.

It is, however, important to note that the discourse reflected in the results and discussion of this study, while a dominant one, is one of many discourses. This study is designed to investigate political and ideological discourse that has the potential to reinforce mechanisms of social dominance and hierarchy. It is therefore a perspective investigating the dominant political discourse surrounding technologies in health while grounded in a contextual focus on socioeconomic inequalities. Other perspectives would, of course, highlight a myriad of other discourses that exist alongside this discourse.

Legitimization – goal or consequence

It may appear that the overall legitimization of innovative health technologies is driven by an explicit and ideological aspiration to actively support and promote the development, adoption and diffusion of these innovations. However, this legitimization discourse may rather be a consequence of the influential power of innovative technologies in society (i.e. non-neutrality). Under current economic incentives, innovative technology development is both inevitable and imperative. The traditional economic rationale is one where social welfare is a product of economic growth, where economic growth relies on corporate advantage, and where corporate advantage is encouraged by innovative product development [1]. Technology has therefore become synonymous with innovation and innovation synonymous with economic superiority (i.e. 'innovate or die'), echoing sentiments of technological determinism [53, 54].

When innovative technologies underpin national identities and economic superiority in a globalized economy, it becomes imperative that these technologies be politically institutionalized in order to gain control over them [1]. It can then be argued that legitimization is a natural consequence, rather than a goal, and therefore becomes a central theme in political discourse. Public health and care services become just another sector in society to be affected, as technological innovations expand into this sector and the promise of commercialization and economic efficiency grows [2, 3].

From the perspective of the present discourse, this legitimization presents itself as a well-known semantic strategy characterized by positive self-representation and negative other representation [18]. In this case, the pro-innovation bias dominating the present discourse (as well as much of modern Western political discourse), represents technological innovation (the 'desired self') as inherently good for society and simultaneously represents the non-technological alternative (the 'other') as negative or counterproductive to society's values and desires [1]. Innovative technologies are rarely problematized and, when are, this is most often in relation to barriers that impede on political aspirations such as safe and socially acceptable implementation of these technologies. Larger social concerns that may question the position or aggregate value of technological innovations in society are left largely unaddressed. This discussion is instead replaced with a pro-innovation ideology and a legitimization discourse (what some also characterize as a neo-liberal discourse) focused on empowerment, self-responsibility, and economic advantage [2, 3, 5].

This strategy of positively self-representing innovative health technologies, and negatively representing any alternative, is a way of managing the impressions of technological innovations [18]. Managing impressions of technological innovation in the political discourse provides

the government with a method of gaining control over technology's position in society. This control allows for directing socioeconomic priorities and general social acceptance of technological innovations, while strategically positioning the government to capture (often economic) benefits that might accrue from these technologies, even if many of the social benefits that tend to dominate the political discourse lack sufficient scientific evidence [7].

Social inequality – an unintentional and undesirable consequence

The discursive legitimization of innovative health technologies with a focus on empowerment begs the question: Who is empowered by these new technologies? The emerging trends in these documents provide a clear indication that the government will actively promote the development, adoption and diffusion of new technologies in health, particularly through national policy-making and municipal responsibility. Simultaneously, the government has a clear agenda to provide equal health and care services for all, which the government is in fact bound to by law following the introduction of the 2012 health law. However, the discourse surrounding health technologies represented in these documents presents several relevant paradoxes that are left, at best, unaddressed and, at worst, unrecognized.

First, these apparently empowering technologies may not result in an aggregate increase in independence but instead merely relocate the source of dependence. Technologies that dominate the present discourse are those that geographically relocate service and care in and around the home and body of the patient or user. This is presented as a means of freeing the individual from using traditional, institutionalized services and empowering (or challenging) users to gain increased control over their own health and activities of daily living. However, this independence from traditional, institutionalized services also increases daily dependence on technological aids, in some cases using the empowerment discourse as a justification for creating entirely new technologically dependent interventions, including replacing activities not traditionally delivered by the health sector [6, 7]. This type of 'personalized,' rather than 'institutionalized,' dependence on technological aids also has the potential to increase individual dependence on the, often commercial, producers of these technologies and the consequences this dependence may promote, as Lupton has also highlighted and discussed in detail [2, 55].

Relevant for social inequalities is the potential that a loss in autonomy resulting from these technologies is strongest for low socioeconomic status (SES) individuals, who are often less active and engaged users and therefore capture fewer benefits [10]. Conversely, these technologies may increase autonomy for higher SES individuals who often experience better overall health, are more active and

engaged users of these technologies, and have a number of other resources at their disposal to promote or improve health [9, 11, 14]. This may result in what can be characterized as a technology-based double burden for low SES individuals, who generally obtain less overall benefits from these technologies yet are more dependent on the benefits they manage to obtain.

Secondly, as suggested by the previous argument, a resource such as innovative technologies, with genuine potential to offer benefits to society, has an equally strong potential to *increase* social inequalities in health as it does to *reduce* social inequalities in health. Here, we can revisit our original question, *Who is empowered by these technologies?* It is well known that higher SES individuals tend to adopt innovative technologies earlier than lower SES individuals and often accumulate benefits from early adoption that are unavailable to later adopters [12]. It is also documented that variations in the use of health technologies tend to benefit high SES individuals [9, 11]. These effects are expected to be particularly strong for technologies that are most often accessed and used directly by end-users (such as consumer and home-based technologies), exactly the technologies that increasingly characterize the political priorities expressed in the current discourse [9]. The availability, and informed use, of these resources are particularly dependent on the physical and non-physical resources already at an individual's disposal, including quality of housing, finances, social network, and health and technology literacy.

It is also expected that high SES individuals would, due to their level of engagement with the technologies, be more influential in development and implementation processes [12]. There is a risk that high SES individuals are often better represented by research and data, market forces, and political power that, in turn, shape the way these technologically innovative resources are developed, adopted and implemented in society [11–13]. Electronic patient journals serve as an interesting example. These technological tools are, in Norway, theoretically available to every citizen (national system). However, physical access is further dependent on stable internet connection and an electronic device that is capable of connecting to the internet [4, 10]. Given physical access, the ability to effectively use these tools, as well as transfer the information in these journals to meaningful benefits for health and care, is dependent on an individual's cultural, legal, technical and medical literacy level [4, 10]. Furthermore, due to mechanisms referenced earlier, the most active and engaged users of these technologies (i.e. high SES individuals and health care professionals) will inspire development and implementation processes, further solidifying this tool's usefulness and personalization for already privileged user groups.

The unfortunate result is, again, what can be characterized as a technology-based double burden for low SES

individuals, who are less likely to be empowered by these technologies and more likely to be alienated from the potential benefits of these resources over time. It is unclear if the role and responsibility of municipalities represented in the discourse may contribute to a reproduction of these individual inequalities or instead prevent the growth of individual inequalities while reproducing regional inequalities.

Conclusion

Despite an overt political imperative for reducing social inequalities in health, the Norwegian political discourse surrounding health technologies presented here gives little attention to the potential for these innovations, such as e-Health and welfare technologies, to unintentionally (re) produce social inequalities. Instead, the discourse is characterized by neoliberal undertones that individualize and commercialize public health and promote a pro-innovation ideology. Broader social concerns with implications for unequally (re) distributing resources and power in society are left largely unaddressed.

The potential of health technologies to deliver positive aggregate value to society is dependent on broad recognition of these often unintended and undesired social consequences. These perspectives should be further integrated into policy agendas if the development, adoption and implementation of innovative health technologies is to, in fact, contribute to equal empowerment and a reduction of social inequalities in health. As these technologies increasingly occupy 'every possible temporal and spatial location' in society, they contribute to a growing medicalization of society [2, 5]. The increased promotion of these technologies as tools for monitoring and surveillance increase the potential for issues of social control and domestication [2, 7]. These, and related issues, are likely to be unequally shouldered by underprivileged groups in society. Therefore, as it becomes more difficult for individuals to opt-out of the technological imperative, political discourses that uncritically promote these innovations will encourage a form of enforced social coercion and, consequently, an abuse of political power. Therefore, recognizing and addressing these issues requires a critical perspective towards the dominant political discourse to understand how it may systematically undermine, even legally mandated, efforts to reduce social inequalities. Moreover, although one must be careful when generalizing the findings from this analysis to a larger international context, it should be noted that the mechanisms driving the current discourse are neither unique to a Norwegian nor a Scandinavian context and are instead often a product of international sociopolitical and socioeconomic trends. Therefore, we would expect to find similar discourses and similar consequences across national and continental divides, particularly where health technologies form a political and/or economical imperative.

Appendix 1**Table 1** Overview of documents included in the discourse analysis

Document	Document Type	Publishing Organization	Parts of the document analyzed	Year Published
[†] Mer Helse for hver Bit	Action plan	Sosial- og helsedepartementet (Social and Health Ministry)	In full	1997
^{††} Telemedisin i Norge	Technical report	Sosial- og helsedepartementet (Social and Health Ministry)	Chp. 1, 3.1, 5.1, 5.3, 5.4, 5.5, 5.6, 6.1, 6.2, 6.3, 6.4, 7.1, 7.2	1998
[†] Si @ Statlig Tiltaksplan	Action plan	Sosial- og helsedepartementet (Social and Health Ministry)	In full	2001
^{††} St. meld. 16 Resept for et sunnere Norge	White paper	Helse- og omsorgsdepartementet (Health and Care Ministry)	Chp: 1.1–1.5, 2, 5, 10.1.1, 10.3.2	2002
[†] Sampspill 2007, Elektronisk samarbeid i helse- og sosialsektoren	Action plan	Sosial- og helsedepartementet (Social and Health Ministry)	In full	2004
^{††} St. meld. 20 Nasjonal strategi for å utjevne sosiale helseforskjeller	White paper	Helse- og omsorgsdepartementet (Health and Care Ministry)	Chp: 1.1–1.6, 7.2.2, 7.2.3	2007
[†] Helsevesenet 2013 IKT Perspektivet	Technical report	Kompetansesenter for IT i helse- og sosialsektoren, KTH (Competence center for IT in health & social sector)	In full	2008
^{††} St. meld. 7 Et nyskapende og bærekraftig Norge	White paper	Helse- og omsorgsdepartementet (Health and Care Ministry)	Chp: 1.1–1.3.3, 2.1, 2.2, 2.3, 2.4.1, 2.4.2, 8.2–8.2.4	2008
[†] St. meld. 47 Samhandlingsreformen	White paper	Helse- og omsorgsdepartementet (Health and Care Ministry)	Forward; chp: 1, 2, 3.4.1	2008
[†] Sampspill 2.0 strategiplan 2008–2013	Action plan	Helse- og omsorgsdepartementet (Health and Care Ministry)	In full	2008
[†] Gode helseregistre - bedre helse 2010–2020	Action plan	Helse- og omsorgsdepartementet (Health and Care Ministry)	Summary; introduction; chp: 5–5.3, 6.4, 8–8.3, 9–9.1, 9.4, 10.2.3, 10.2.10, 11.2, 11.4	2010
^{††} NOU innovasjon i Norge	Public inquiry	Helse- og omsorgsdepartementet (Health and Care Ministry)	Chp: 7	2011
[†] St. meld. 16 Nasjonal helse- og omsorgsplan 2011–2015	White paper	Helse- og omsorgsdepartementet (Health and Care Ministry)	Summary; chp: 2, 3, 3.1, 3.3, 4, 5, 6, 6.3, 7, 8, 8.4, 8.5	2011
^{††} Nasjonal strategi for bioteknologi 2011–2020	Action plan	Kunnskapsdepartementet (Knowledge Ministry)	Forward; summary; chp: 1, 2.3, 3.5, 4.1	2011
[†] Regjerings digitaliseringsprogram	Action plan	Departementene (The Ministries)	Foreward; summary; chp: 4.2	2012
[†] St. meld. 9 En innbygger, én journal	White paper	Helse- og omsorgsdepartementet (Health and Care Ministry)	In full	2012
[†] St. meld. 10 Gode kvalitet, trygge tjenester	White paper	Helse- og omsorgsdepartementet (Health and Care Ministry)	Summary; chp: 4–4.8, 6.4, 8.1, 9, 9.3–9.3.2	2012
[†] St. meld. 11 Personvern	White paper	Kongelege fomyings-, administrasjons- og kyrkjedepartementet (Royal Renewal, Administration and Church Ministry)	Summary; chp: 2, 2.1, 2.4.4, 2.4.10, 4.2, 4.10, 5.5, 5.6, 5.9, 6.5, 6.6, 7.7, 8.11, 9.1, 9.3.3, 9.7, 10.9, 11	2012
[†] St. meld. 23 Digital agenda for Norge	White paper	Kongelege fomyings-, administrasjons- og kyrkjedepartementet (Royal Renewal, Administration and Church Ministry)	Introduction; chp: 2, 3.1.1, 6, 10, 11, 12	2012
[†] St. meld. 29 Morgendagens omsorg	White paper	Helse- og omsorgsdepartementet (Health and Care Ministry)	Introduction; summary; chp: 7, 8, 9	2012
[†] St. meld. 34 Folkehelsemelding	White paper	Helse- og omsorgsdepartementet (Health and Care Ministry)	Introduction; chp: 2.1.2, 3.1, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 6.2.2	2012
^{††} Fagrapport om implementering av velferdsteknologi i de kommunale helse- og omsorgstjenestene 2013–2030	Technical report	Helsedirektoratet (Health Directorate)	Forward; introduction; summary; chp: 1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18	2012
^{††} Helseomsorg21 – Et	Action	Helse- og omsorgsdepartementet	Pages: 6–8, 13–18, 36, 38, 42, 45, 47, 49, 50–52,	2014

Table 1 Overview of documents included in the discourse analysis (Continued)

Document	Document Type	Publishing Organization	Parts of the document analyzed	Year Published
kunnskapssystem for bedre folkehelse	plan	(Health and Care Ministry)	54, 61, 79, 80–82, 85–88, 89, 91, 100–110, 113, 115, 117, 118, 121, 125–130, 133, 134, 140, 143, 144, 146, 149, 153, 155	
[†] St.meld. 11 Kvalitet og pasientsikkerhet	White paper	Helse- og omsorgsdepartementet (Health and Care Ministry)	Chp: 1, 9, 9.1, 9.2, 9.3, 9.4	2014
[†] St.meld. 19 Folkehelsemelding	White paper	Helse- og omsorgsdepartementet (Health and Care Ministry)	Chp: 1–1.5, 3.1, 4.5, box 4.7, 9.1.1, 9.1.2	2014
[†] St.meld. 26 Fremtidens primærhelsetjeneste	White paper	Helse- og omsorgsdepartementet (Health and Care Ministry)	Chp: 1–5, 15.4, 18–18.5	2014
[†] St.meld. 28 Leggemiddelmeldingen	White paper	Helse- og omsorgsdepartementet (Health and Care Ministry)	Chp: 1, 2–2.4, 3–3.4, 4–4.7, 7.1.3, 7.2.1, 8, 18, 19, 19.4.4, 20, 21, 22.4, 22.4.3, 22.5.3, 23–23.4, 24–24.1.3	2014
^{††} Første gevinstrealiseringsrapport – Nasjonalt velferdsteknologi-program	Technical report	Helsedirektoratet (Health Directorate)	Chp: 1.1, 1.2, 2, 3, 5.1, 5.2, 5.3	2015
[†] St.meld. 11 Nasjonal helse- og sykehusplan	White paper	Helse- og omsorgsdepartementet (Health and Care Ministry)	Chp: 1, 2, 3, 4, 4.1, 4.2, 5, 5.1, 5.3, 5.4, 6, 7, 7.5, 9, 9.7, 12.4, 15, 15.1, 15.2, 19, 21.3	2015
^{††} The Government action plan for implementation of the Health&Care21 strategy	Action plan	Departementene (The Ministries)	Foreword; introduction; chp: 8, 10, 13, 14, 15, 23, 24, 27, 28	2015
^{††} Andre gevinstrealiseringsrapport – Nasjonalt velferdsteknologi-program	Technical report	Helsedirektoratet (Health Directorate)	Chp: 1.1, 1.2, 2.1, 2.2, 4.1–4.3	2017
[†] Nasjonal e-helse strategi og mål 2017–2022	Action plan	Direktoratet for e-Helse (Directorate for e-Health)	In full	2017
[†] Nasjonal handlingsplan for e-helse 2017–2022	Action plan	Direktoratet for e-Helse (Directorate for e-Health)	In full	2017

[†]Documents included by recommendation from official Norwegian directorates

^{††}Documents included from hand search or snowball method

Appendix 3

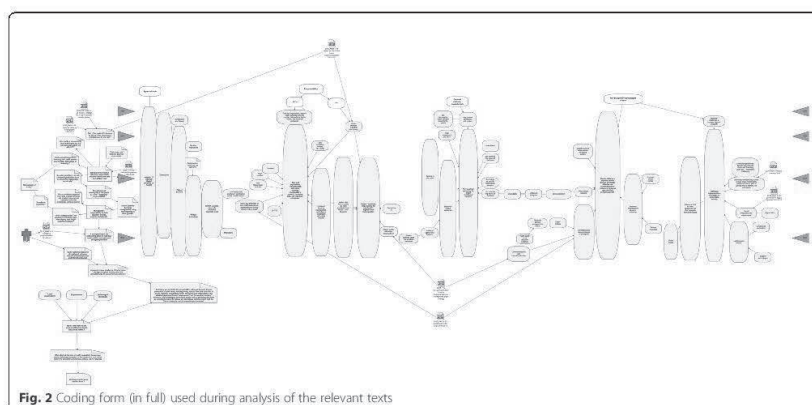


Fig. 2 Coding form (in full) used during analysis of the relevant texts

Abbreviations

CDA: Critical discourse analysis; EPJS: Electronic patient journals; ICT: Information and communication technologies; RTH: Norwegian Competence center for information technologies in the health and social sector; SES: Socioeconomic status

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Authors' contributions

DW is the sole author and therefore responsible for all work associated with this manuscript. All authors read and approved the final manuscript.

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12 APPENDIX

12.1 HUNT I QUESTIONNAIRE

HUNT 1 Questionnaire 2c Diabetes

Page 1

You have stated that you have diabetes. One of the main goals of this study is to find ways to treat diabetes that, as much as is possible, avoid discomfort.

We ask therefore that those who suffer from or have suffered from diabetes answer these questions on diabetes to the best of their abilities.

You may have completed a similar form in the autumn of 1982. Nevertheless, it is very important that you complete this form as well.

All information will be treated in the strictest confidence.

Thank you !

When were you first diagnosed with diabetes?

(Write the year in the box) <year>

Under what circumstances were you diagnosed with diabetes?

I consulted a doctor because of symptoms

It was discovered without my having symptoms (examination for a medical certificate, company medical examination, examination for another complaint at a hospital or elsewhere)

What symptoms did you have around the time the diabetes was discovered?

(Place an X in more than one box if applicable)

None

Abnormal thirst

Excessive urination

Lethargy

Weight loss

Vaginal itching

Other symptoms

If OTHER SYMPTOMS, specify:

Has your mother, father, siblings or your children had diabetes? <yes, no>

If YES, do or did any of them take insulin injections? <yes, no>

TREATMENT

Do you take insulin injections? <yes, no>

If YES, do you inject insulin daily?

Injection once a day

Injection twice or more times a day

If you inject insulin, how much insulin, in total, do you take every day?

(Write the number of ml in the box - 1 "line" corresponds to 0.1 ml) <ml>

If you inject insulin, what is the name of the insulin you use?

(Write the name written on the bottle, both names if you use two types)

Do you take tablets for your diabetes? <yes, no>

If you take tablets for your diabetes, write the name of the tablets below, the mg written on the bottle/packet and the number of tablets you take per day:

(If you take more than one type of tablet for your diabetes, write the names of both)

Write the name of the tablet here mg pr. tabl. no.pr.day

Write the name of the tablet here mg pr. tabl. no.pr.day

How many meals do you eat a day? <number>

Do you feel you know enough about the kinds of food you can eat? <yes, no>

If you were to say what you actually eat rather than what your doctor says you should eat, would you say that you:

(Only put an X in one box, the one that is most like what you actually do)

Eat more or less the same as those who do not suffer from diabetes

Eat what I like, but not sugar and sweets

Use approximately measured quantities of bread, potatoes, milk and fruit

Weigh/measure specific quantities of bread, potatoes, milk and fruit one or more days a week

Do you check the quantity of sugar in your urine at home?

(Answer YES if somebody helps you or does it for you.) <yes, no>

What is the name of the method you use to measure the sugar in your urine?

Write the name on the package here:

Do you check how much sugar you have in your blood (blood sugar level) at home?

(Answer YES if somebody helps you or does it for you.) <yes, no>

What is the name of the method you use to measure your blood sugar?

Write the name on the packet and the name of any instrument you use for measuring:

If you check the sugar content in you urine or blood yourself, how often do you do so?

(Answer how often also if somebody helps you or does it for you; place an X in the appropriate box.)

- Every day
- 2 - 3 days of the week
- Once a week
- Every fortnight
- Once a month
- Less than once a month

Page 2

If the sugar level in your urine or blood is checked at home, do you take the measurement several times a day the days this is done? <yes, no>

If urine or blood samples are taken at home, do you take the results with you to your doctor when you go for medical examinations?

(Place an X in the appropriate box)

- Never
- Sometimes
- Usually
- Always

Do you see a doctor regularly for your diabetes? <yes, no>

If YES, how much time passed between the last two times you visited your doctor for your diabetes examination?

Number of months (write in the box) _____

What type of doctor do you see regularly for your diabetes?

(Place an X in only one box)

- Ordinary doctor (local medical officer, general practitioner, company doctor, etc.)
- Hospital doctor (outpatient department at hospital)
- I live in a nursing home or other institution and am examined there
- Other

If OTHER, write what type of doctor on the line above.

OTHER ILLNESSES

Do you regularly take medicine for anything other than diabetes? <yes, no>

If YES, write the name of these medicines

(Write the name that appears on the bottle or packet. Include all medicines taken on a regular basis. Place an X behind the name of any medicine that you took before you were diagnosed with diabetes.)

Do you believe that people are more vulnerable to certain illnesses if their diabetes is not properly controlled? <yes, no>

If YES, write the names of 3 such illnesses

(You need not have suffered from these illnesses yourself)

Have you suffered from any lasting (chronic) complaints since having diabetes?

(Write illnesses/complaints on the lines below)

INSTRUCTION - SUPPORT

Are you a member of the Norwegian Diabetes Association? <yes, no>

Have you ever attended courses or meetings on diabetes? <yes, no>

Are you receiving basic benefits for your diabetes from social security? <yes, no>

Have you applied for and been granted a tax allowance because you have diabetes? <yes, no>

HOW DO YOU FEEL?

Do you find having diabetes difficult?

(Place an X in the appropriate box)

Yes, I feel it is a problem everyday

Yes, I think about it a lot

Yes, sometimes

No, rarely

No, I hardly ever think about it

I feel I am the same as people who do not have diabetes

If you find it difficult having diabetes, what do you like least?

(Write your opinion on the line below)

Do you tell others that you have diabetes?

(Place an X in the appropriate box)

Yes, always if I think they should know

Yes, but only if they ask

No, prefer not to

It worries me that people might find out

Has your blood sugar level ever been too low (“hypoglycaemia”, “insulin shock”)?

<yes, no>

If YES, how many times has this happened in the last week?

(Write the number of times in the box) _____

How many times have you been hospitalized during the last 5 years?

(Write the number of times in the box) _____

If you have been hospitalized during the last 5 years, state why?

(Write on the lines below)

12.2 HUNT II QUESTIONNAIRE

HUNT 2 Questionnaire 3

Supplementary form on **diabetes**

Page 1

You have stated that you have, or have had, diabetes. Therefore, we ask that you answer these questions to the best of your knowledge. The information will be used for research to improve diabetes care and to prevent problems associated with the disease. Please read the brochure 'hunt-special' that you received at the health examination.

All information will be treated in strict confidence.

COMPLETION

Date of completion of the form ___/___/19___

DIAGNOSIS

Under what circumstances were you diagnosed with diabetes?

I consulted a doctor because of symptoms <yes, no>

It was discovered without my having symptoms (examination for a medical certificate, company medical examination, examination for another complaint at a hospital or elsewhere) <yes, no>

What symptoms did you have around the time the diabetes was discovered? (Put an X in at least one box)

No symptoms	Nausea
Abnormal thirst	Vision problems
Excessive urination	Leg pain
Lethargy, faintness	Vaginal itching (Genital pruritus)
Weight loss	Other symptoms

TREATMENT

INSULIN

Do you take insulin injections (syringe, pen) for your diabetes? <yes, no>

If NO, go to TABLETS

What year did you begin taking insulin? 19 ____

How do you take insulin? *One X on each line* <yes, no>

Syringes that I fill myself

Disposable (ready-filled) insulin pens

Standard insulin pens (pens with ampoules that are changed when empty)

Insulin pump

Jet injector

How many times a day do you normally take insulin? No. of times ____

How many units of insulin a day do you normally take? Units (IU) ____

TABLETS

Do you take tablets for your diabetes? <yes, no>

If NO, go to MEASURING YOUR BLOOD SUGAR

If you take tablets for your diabetes, write the name of the tablets below, the mg written on the bottle/packet and the number of tablets you take per day:

(If you take more than one type of tablet for your diabetes, write the names of both)

Write the name of the tablet here mg pr. tabl. no.pr.day

Write the name of the tablet here mg pr. tabl. no.pr.day

MEASURING YOUR BLOOD SUGAR

At home, do you measure how much sugar (glucose) you have in your blood (blood sugar)?

Answer yes if someone helps you or does it for you <yes, no>

If NO, go to MEDICAL EXAMINATION

Approximately how many times do you measure your blood sugar in an average week? No. of times ____

What method do you use to measure your blood sugar?

Blood test strips (read by comparing to colour on box):

Blood glucose monitor (reads sample; gives result as a number):

If you use a monitor to read your blood sugar level, what is the device called? Write the name on the line

MEDICAL EXAMINATION

Do you see a doctor regularly for a medical examination for your diabetes? <yes, no>

If NO, **do you go to a nurse or other health care personnel for your medical examination?** <yes, no>

If you do not go to your doctor for medical examinations, go to DIET

What type of doctor do you see regularly for your diabetes?

(Put an X in only one box)

Ordinary doctor (local medical officer, general practitioner, company doctor, etc.)

Hospital doctor (outpatient department at hospital)

I live in a nursing home or other institution and am examined there

How many different doctors have there been the last five times that you went for your usual diabetes examination? Number of doctors _____

How many times a year do you usually go to the doctor for a diabetes examination? No. of times _____

Page 2

DIET

Here are a few statements about diet and food. Answer according to your average daily diet.

One X for each line

<True, Somewhat true, Somewhat false, False>

I eat exactly the same as those without diabetes.

I constantly try to lose weight.

I see it as a problem not to be able to eat what I want.

On most days I try to avoid (saturated) fat.

I eat a lot of vegetables.

HOW ARE YOU

Do you find having diabetes difficult? *One X only*

Yes, I feel that it is a problem every day

Yes, I often think about it

Yes, sometimes

No, rarely

No, I hardly ever think about it

Has your blood sugar level ever been too low ("hypoglycaemia", "insulin shock")?

<yes, no>

If YES, **how many times has this happened in the last week?** No. of times _____

Has your blood sugar been so low (insulin shock) that you needed someone to help you recover? <yes, no>

How many times have you been hospitalized since you were diagnosed with diabetes? No. of times _____

If you have been hospitalized since you were diagnosed with diabetes, what was the reason?

Write on the lines below

VISION

Do you have problems with your vision that your doctor has said are related to your diabetes? <yes, no>

MEDICATION

Do you regularly take any medication for anything other than your diabetes? <yes, no>

If YES, **give the names of these medicines.** Write the name that is on the bottle or pack. Include all regularly taken medicine.

INSTRUCTION - SUPPORT

Are you a member of the Norwegian Diabetes Association? <yes, no>

If YES, **for about how many years have you been a member?** Years ____

Have you ever attended courses or meetings on diabetes? <yes, no>

Are you receiving basic benefits for your diabetes from social security? <yes, no>

Do you receive a special tax allowance because you have diabetes? <yes, no>

FOOT PROBLEMS

Have you undergone surgery for intermittent claudication (blocked artery/smoker's leg)? <yes, no>

Have parts of one or both legs been amputated? One X on each line, write the year on the right

toe/foot? <yes, no> Year _____

calf/knee? <yes, no> Year _____

thigh? <yes, no> Year _____

Have you had ulcers on your feet that have taken more than 3 weeks to heal? <yes, no>

If YES, **about how many weeks did it take for the ulcers to heal?** Weeks _____ (If several times, answer for the time that lasted the longest)

Have you ever had your feet examined by the doctor at your normal diabetes examination?

<Yes, No, Don't remember>

Are your feet examined regularly by any of the following? <yes, no>

Doctor

Foot therapist/pedicurist

Nurse/home care nurse

Other

Yourself

If you have regular foot examinations by the doctor/foot therapist/nurse, how long is it between examinations? Weeks _____

Please put this questionnaire in the same envelope as the other questionnaires that you were given at the health examination and post them as soon as possible.

The postage is paid.

Many thanks for your help!

12.3 HUNT III QUESTIONNAIRE

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T

7

Q3 Questionnaire 3
Diabetes

†

1

†

Dear HUNT participant,

Thank you for participating in the first part of this health study. You have received this questionnaire because you answered Yes to the question about diabetes. We hope that you will also answer this questionnaire. Please put an X in the box of your answer for each question using a blue or black ball point pen or marker. CORRECT INCORRECT

Return the questionnaire in the enclosed, stamped envelope.

Date of completion ____ / ____ 200 ____

DIAGNOSIS

Under what circumstances were you diagnosed with diabetes? Yes No

I consulted a doctor because of symptoms

It was discovered without my having symptoms

(Examination for a medical certificate, company medical examination, examination for another illness, etc.)

In which year were you diagnosed with diabetes?

Write the year in the appropriate box; Example below:

19 95

TREATMENT

INSULIN

Do you currently take insulin (syringe, pen) for your diabetes? Yes No

If No, skip to question 8

What year did you begin taking insulin?

19 95

How do you take insulin? (One X for each line)

Insulin pen Yes No

Insulin pump

Jet injector

How many times a day do you normally take insulin? Number of times

How many units of insulin a day do you normally take? Units (IU)

TABLETS

Do you take tablets for your diabetes? Yes No

What year did you begin taking tablets for your diabetes?

19 95

MEASURING YOUR BLOOD SUGAR

At home, do you measure how much sugar (glucose) you have in your blood (blood sugar)? (Answer Yes if someone helps you or does it for you) Yes No

Approximately how many times do you measure your blood sugar in an average week/day? (Write in the box that is appropriate for you)

Pr. week: Pr. day:

MEDICAL EXAMINATION

Do you see a doctor regularly for a medical examination for your diabetes? Yes No

If No,

Do you go to a nurse or other health care professional for your medical examination? Yes No

If you do not go to a doctor for medical examinations, skip to question 16.

What type of doctor do you see regularly for your diabetes? Yes No

Family doctor (general practitioner, company doctor, etc.)

Hospital doctor (outpatient department at hospital)

I live in a nursing home or other institution and am examined there

How many different doctors have there been the last five times you went for your usual diabetes examination? doctors

How many times a year do you usually go to the doctor for a diabetes examination? times

INSTRUCTION - SUPPORT

Are you a member of the Norwegian Diabetes Association? Yes No

If Yes, about when did you become a member?

19 ____ 200 ____ Write the year in the appropriate box

Have you ever attended courses or meetings on diabetes? Yes No

Do you receive a special tax allowance because you have diabetes? Yes No

Where did you get the most information about diabetes?

- X the most important places (up to 3):
- Course/meetings
 - My doctor, other doctor
 - Nurse (diabetes nurse)
 - Others who have diabetes
 - Books/magazines/journals
 - Internet

DIET AND FOOD

Below are a few statements about diet and food. Answer according to your average daily diet (One X per line)

	True	Somewhat true	Somewhat false	False	
I eat exactly the same as those without diabetes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
I constantly try to lose weight	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
I see it as a problem that I cannot eat what I want	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
On most days I try to avoid saturated fat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
I eat a lot of vegetables	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
How often do you usually eat:					
	Seldom/ Never	1-2 x a week	3-4 x a week	5-6 x a week	Every-day
nuts?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
peas/beans/lentils?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
oatmeal?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
onions?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

VISION

Do you have problems with your vision that your doctor has said are related to your diabetes? Yes No

Do you regularly go to eye examinations (of retina) because of your diabetes? Yes No

If Yes:

How long is it usually between examinations? Months

Have you had laser eye surgery because of changes in the retina caused by diabetes? Yes No

HOW ARE YOU

Do you find having diabetes difficult? (One X)

Yes, I feel that it is a problem every day

Yes, I often think about it

Yes, sometimes

No, rarely

No, I hardly ever think about it

I feel just like those who do not have diabetes

In general, do you think it is difficult to control your blood sugar?

Very difficult Easy

Difficult Very easy

Sometimes difficult/sometimes easy

Has your blood sugar level ever been too low ("hypoglycaemia", "insulin shock")? Yes No

If Yes,

How many times has this happened in the last week? Times

Has your blood sugar been so low (insulin shock) that you needed someone to help you recover? Yes No

How many times have you been hospitalized since you were diagnosed with diabetes? Times

If you have been hospitalized since you were diagnosed with diabetes, what was the reason?

Low sugar/insulin shock or injury due to this

High blood sugar/hyperglycaemia

Cardiovascular disease (heart attack, heart failure, stroke, etc.)

Kidney disease

Other illness/disease

LEG/FOOT PROBLEMS

Have you undergone surgery for blocked arteries? Yes No

Have parts of one or both legs been amputated? (One X for each line, if Yes, write in year on the right)

	Yes	No	Year
Toe/foot	<input type="checkbox"/>	<input type="checkbox"/>	<input type="text"/>
Calf/knee	<input type="checkbox"/>	<input type="checkbox"/>	<input type="text"/>
Thigh	<input type="checkbox"/>	<input type="checkbox"/>	<input type="text"/>

Have you had ulcers on your feet that have taken more than 3 weeks to heal? Yes No

If Yes,

About how many weeks did it take for the ulcers to heal? (If several times, answer for the time that lasted the longest) weeks

Have you ever had your feet examined by the doctor at your normal diabetes examination? Yes No Don't remember

Are your feet examined regularly by any of the following? (X all that have done this)

Doctor Other

Foot therapist/pedicurist Yourself

Nurse/home care nurse

If you have regular foot examinations by the doctor/foot therapist/nurse, how long is it between examinations? Months

Return the questionnaire in the accompanying, stamped envelope.

Thank you for your help!