THE FUTURE IS NOW

Exploring anticipatory practices in MedTech governance

Reneé Else Michels

Over de cover

De uil op de cover staat symbool voor anticipatie, wijsheid en toekomsgerichtheid – onderwerpen die centraal staan in mijn verkenning van anticipatory practices in MedTech governance. De keuze voor de uil is ook persoonlijk. De lithografie op de cover van dit proefschrift is gemaakt door mijn oom, Erik Renssen. De uil was bovendien het lievelingsdier van mijn oma, aan wie ik mijn tweede naam te danken heb. Zo vormt de uil niet alleen een academisch symbool, maar ook een brug naar mijn eigen familiegeschiedenis. Daarnaast duikt de uil telkens op in talloze imaginary worlds – werelden in boeken die soms een welkome uitvlucht bieden uit de werkelijkheid, maar ons ook uitnodigen om ons voor te stellen hoe het anders kan zijn. En juist die verbeeldingskracht is onmisbaar wanneer we nadenken over de toekomst van technologie en governance.

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The Future is Now: Exploring Anticipatory Practices in Medtech Governance

De toekomst is nu: onderzoek naar anticiperende praktijken
binnen MedTech governance

Thesis

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Introduction

It is the beginning of fall 2020. I am applying for a PhD position on the governance of medical technology (MedTech). In my job at the time, I conduct Health Technology Assessments (HTAs) of mainly innovative pharmaceuticals, in an attempt to reduce some of the uncertainty surrounding their market introduction and reimbursement through public health resources, with examples including 'esketamine' (for treatment-resistant depression), 'axicabtagene ciloleucel' (for lymphoma), or 'larotrectinib' (for a range of cancer types). HTA is defined as "a multidisciplinary process that uses explicit methods to determine the value of a health technology at different points in its lifecycle. The purpose is to inform decision-making in order to promote an equitable, efficient, and high-quality health system" (O'Rourke et al., 2020, p. 188). A common HTA method is cost-effectiveness analysis, in which the costs and effects of innovative technologies are compared to the current standard of care, often through modelling. I submit our HTA reports to HTA agencies, for them to formulate advice on whether the pharmaceuticals in question should be reimbursed through public resources. In the Netherlands, our reports are submitted to the Dutch HTA agency: the National Health Care Institute (Zorginstituut Nederland or 'ZIN').

At the time, I am increasingly contacted by medical technology (MedTech) companies, with innovative technologies such as wound dressings, artificial heart valves, and digital health applications. I cannot find a standardized HTA process for MedTech innovations, and I am unsure where to begin. What's more, the pharmaceuticals I assess also increasingly do not fit the standardized HTA methods I apply. The HTA methods I work with, developed to assess the impact of innovative health technologies, seem to constantly clash with the realities of such innovation. The PhD vacancy text appeals to me: "Conventional means of regulating these new technologies may not be feasible nor sufficient to ensure the quality, accessibility, and affordability of technology in healthcare." (ESHPM, 2020).

My confusion is reflected in academic literature. Several scholars discuss the applicability of HTA to MedTech, showing that although HTA is increasingly applied to MedTech, challenges remain. These include the need for 'well-designed' randomized clinical trials (RCTs), 'short' product lifecycles, and 'inexplicit' target populations for the technology under assessment (Ming et al., 2022). Others contemplate how learning curves of MedTech users (e.g., doctors using a surgical tool) influence the evidence, or how the iterative development of MedTech complicates finding a steady-state evaluation period (Bluher et al., 2019; Ciani et al., 2015; Crispi et al., 2019; Enzing et al., 2021; Ming et al., 2022). Based on this literature, it seems that HTA (as a conventional means of governing technologies) may indeed not be feasible or sufficient to ensure the quality, accessibility, and affordability of healthcare.

Fast forward to today. This dissertation is the result of more than four years of research within and around ZIN that I have conducted in the context of the aforementioned PhD project. In this dissertation, I reflect on the relationship between MedTech innovation and governance. I examine several dimensions of this relationship, such as uncertainty, expectations, evidence, institutional roles, and different knowledge practices between different actors. Here, governance is intended to mean "a wider set of activities than mere government" (Guston, 2010, p. 434). The emphasis is on '"governing activities that are broadly distributed across numerous actors" (Guston, 2014, p. 226). These actors include, for example, the aforementioned HTA agencies, private MedTech industry actors, scientific experts, regulatory agencies, patient organizations and funding agencies.

In particular, I zoom in on the day-to-day level of futureproofing MedTech governance, by exploring several so-called 'anticipatory practices'. Anticipatory practices are tools that help engage with uncertain futures, deliberate about uncertainties, and guide action in the present, examples including 'HTA' or 'horizon scanning'(Alvial-Palavicino & Konrad, 2019; Muiderman et al., 2020). The overarching research question of this dissertation is as follows:

How are anticipatory practices shaped by and shaping the governance of MedTech?

Below, I will first set the stage by elaborating on what I mean with 'the governance of MedTech', to establish the foundation for this dissertation.

The Governance of MedTech

Defining what constitutes the governance of MedTech is not a straightforward task. For the purposes of this introduction, I would like to present some of the questions and factors that I considered important. The first question is: What is MedTech? As it turns out, the definition of MedTech is complex. In the context of HTA, MedTech is often defined by *what it is not,* namely as a non-pharmaceutical (e.g., Lefebvre et al., 2017). Another prominent definition of MedTech is found in the European Medical Device Regulation (MDR) (EU, 2017a). The definition is 5 pages long and similarly includes an explicit reference to its distinction from pharmaceuticals in the first paragraph, namely "...which does not achieve its principal intended action by pharmacological, immunological, or metabolic means..."(EU, 2017a, p. 15). In the context of their governance, MedTech innovations are often categorized and defined according to their level of risk. For example, the MDR categorizes risk-class I (low risk), IIa and IIb (medium risk), and III (high risk), defining risk as "the combination of the probability of occurrence of harm and the severity of harm" (EU, 2017a, p. 17). For HTA, whether a MedTech is 'innovative' or a 'technical variant' of an existing form of already reimbursed MedTech is also

important, influencing decisions about whether or not a new assessment is necessary for market introduction and reimbursement (Zorginstituut, 2023a).

Throughout my research, I have approached this matter of defining MedTech as an empirical inquiry, investigating how various MedTech stakeholders defined what is and is not considered 'MedTech' and what these distinctions reveal about the governance of MedTech. For the purpose of setting the stage, I find the general definition provided by MedTech Europe to be useful, as it allows for a broad range of technologies to be included. They identify three primary categories within MedTech: Medical devices (products, services or solutions that prevent, diagnose, monitor, treat and care for people), in-vitro diagnostics (non-invasive tests used on biological samples to determine the status of a person's health), and digital health (tools and services that use information and communication technologies (ICTs) to improve prevention, diagnosis, treatment, monitoring and management of a person's health and lifestyle (MedTechEurope, 2022).

Another question is: Who is involved in the governance of MedTech? In this dissertation, I focus mainly on the governance of MedTech within the European context. MedTech innovations can apply for market access in all EU countries at the same time, overseen by Notified Bodies spread across Europe. Developers can self-certify low-risk, class-I innovations without Notified Body involvement. Class II and class III MedTech innovations go through a process called 'conformity assessment', evaluated by Notified Bodies. This process has long been governed by the Medical Device Directive (MDD), but has recently been updated to the Medical Device Regulation (MDR) and the In Vitro Device Regulation (IVDR), which set a higher standard for quality and safety assessment of MedTech (EU, 1993, 2017a, 2017c). At the national level, competent authorities monitor compliance with EU regulations and oversee market surveillance. In addition, health ministries, HTA agencies, and insurers govern the reimbursement of MedTech through national public resources, whilst hospitals, municipalities and patients manage the reimbursement of MedTech at their respective levels.

MedTech is thus governed in a "polycentric regime" (Black, 2008), which means that responsibility is distributed among, and coordinated between, different actors at local, national and supranational levels. Often, MedTech are implemented before evaluation by all relevant actors within this regime. An example from the Dutch policy context is the Proton center. Proton therapy, a highly targeted cancer treatment using proton beams, generated considerable debate since its introduction about whether it was worth the large investment, with decision-makers unable to go back on that decision now that the center had been built and taken into use (e.g., Hordijk, 2021; Jacobs et al., 2022). Partly as a result of the many different actors involved in the polycentric regime,

there are different narratives about what constitutes 'valuable' MedTech. Actors have different expectations and visions of the value of MedTech, ranging from achieving market competition and entrepreneurship to promoting population health, equitable access, universal coverage, or sustainability (Abrishami & Repping, 2019).

As such, there are different objectives for MedTech governance, including but not limited to: safety, quality, efficacy, cost-effectiveness, accessibility, equity, necessity, sustainability, usability, efficiency, transparency, and ethical integrity. This is reflected in the literature on MedTech governance. Some authors argue that MedTech will modernize or even revolutionize healthcare, or that it is inherently valuable to be at the forefront of innovation (e.g., Syeed et al., 2022). Some argue that quality and safety scandals mean that MedTech should be much more tightly regulated (e.g., Campillo-Artero, 2013), while others worry that too much regulation will stifle innovation (e.g., Stojčić et al., 2024). And whilst some argue that the value of MedTech is constructed through its use and cannot be predetermined, others argue that the value of MedTech can be determined before it is widely used (Abrishami, 2018; Bluher et al., 2019).

Another relevant factor is related to MedTech's innovative character. While governance instruments generally aim to provide structure, to control or steer MedTech, MedTech innovations are by definition new and involve change, often with partly unexpected, unpredictable and unintended consequences. This has to do with what is commonly thought to be an inherent friction between innovative MedTech and governance. A recent illustration of this friction is the AI act in Europe (EU, 2024). The AI act, which regulates AI-based MedTech (among other AI-based technologies), was almost ready to be implemented in the beginning of 2021. However, the introduction of ChatGPT, a large language model as a form of generative AI, led to discussions that eventually meant a revision of the regulation, and it took more than three years for the regulation to be reestablished and adopted by the European Commission (EC) (Helberger & Diakopoulos, 2023).

The governance of MedTech thus often takes place whilst it is still developing and therefore changing, introducing further uncertainties for governance efforts. This uncertainty has been conceptualized in various ways, such as the Collingridge dilemma (Collingridge, 1980) or technological momentum (Hughes, 1969). The Collingridge dilemma represents a timing problem, where in the early stages of technology's development there is insufficient information to predict potential future consequences, and in the later stages of technology, when consequences are more concrete, it is often too late to change and manage these technologies, as they are already widely distributed and in use. Technological momentum refers to how MedTech innovations become embed-

ded in social, economic, and political systems, making it difficult to change decisions about MedTech as more information becomes available. In order to address this friction between innovation and governance, both MedTech innovations and governance instruments (such as HTA methods) are often first tested in controlled environments like pilots or sandboxes (Buocz et al., 2023; Elvidge et al., 2024). Here, stakeholders can experiment without having to abide by the full set of rules, reducing the risk of unwillingly setting precedents for other technologies. Questions remain, however, about the translation of insights from shorter term experimental collaborations into longer-term, more institutionalized governance processes (Ryghaug & Skjølsvold, 2021).

A final factor that seems to be complicating MedTech governance is a decreasing sense of trust. Trust in (medical) technologies' safety seems to have declined along with the development of a number of technologies with far-reaching and unpredictable implications (Millstone & van Zwanenberg, 2000). Examples include gene editing technologies, AI, nanotechnologies, synthetic cells, or 3D bioprinting. In addition, a number of recent MedTech scandals have heightened political sensitivity. These include, for example, leaking breast implants (Deva et al., 2019), hip implant erosion (Wienroth et al., 2014), or the recall of potentially unsafe respiratory devices (Owens et al., 2021). The debates on quality and safety issues that followed these scandals have led to greater emphasis on MedTech governance, culminating for example in the introduction of the aforementioned MDR and IVDR (Shatrov & Blankart, 2022).

The Future Is Now?

The developments and questions described above have led to calls for a 'futureproofing' of MedTech governance. The future is a pervasive theme in MedTech governance. Around the time of applying for this PhD, ZIN published a report entitled 'Collaborating on appropriate care: The future is now.' (Zorginstituut, 2020b). The report is written in collaboration with the Dutch Health Care Authority (NZA), another key institution in maintaining the quality and affordability of the Dutch healthcare system. Together, they introduce the concept of Appropriate Care (*Passende Zorg*) and its relevance for "futureproofing" (p. 12, 13, 14, 15, 20) the Dutch health care system. As ZIN and NZA argue: "The future is now. [...] It is time to get moving. It is time for clear language, unambiguous goals, bold agreements and consensus" (Zorginstituut, 2020b, p. 4).

This focus on futureproofing governance is not unique to the ZIN and NZA report. To some extent, all forms of governance deal with the future in one way or another, but the explicit focus on making futureproofing a more structural part of governance processes is a trend that can be observed in many recent policy debates around MedTech. Examples from the Dutch policy arena include the 'Future Panel', proposed by

the Rathenau Institute and Radboud University to stimulate debate on the synthetic cell (Rathenau, 2022). Another example is the report 'A way out of scarcity: On the necessity and promise of medical technology in tackling human resources shortages in healthcare' by Gupta, a Dutch consultancy (Gupta, 2022). Gupta starts their report with a forecast: "By 2031, there will be a shortage of 98,000 healthcare workers"(Gupta, 2022). MedTech is presented as a way out of this predicted future shortage, but it is important to act now: "What are we waiting for?" (Gupta, 2022, p. 24).

One can imagine how making futureproofing a more structural part of governance processes does something to those processes. We are invited to think ahead, and all sorts of expectations and imaginaries of the future enter the debate. In the Future Panel, different visions of what a future that includes a synthetic cell might look like are shared and discussed. The synthetic cell may lead to a more sustainable future, it could privilege certain population groups, or it could develop so fast that regulatory control falls behind (Rathenau, 2022). The Gupta report similarly paints a worrisome future scenario, predicting a huge shortage of health workers (Gupta, 2022). At the same time, we are urged to think about the here and now, through phrases such as 'The future is now' or 'It's time to get moving' (Zorginstituut, 2020b). An emphasis is placed on today's actions, and how these may contribute to the anticipated futures portrayed. In so doing, a sense of urgency is communicated, to produce, control, or avoid certain futures.

What these recent reports also have in common is a call for more multistakeholder collaboration. As the report by ZIN and NZA puts it, the goal is to work together, seeking congruence among relevant stakeholders. Similarly, the Gupta report concludes that it is crucial for all stakeholders to work together in a congruent way, and the Future Panel recommends debate between scientists from different backgrounds, to reflect the similarly divergent views of society. Multistakeholder collaboration is complicated, especially in a context like MedTech governance that consists of different experts, including scientists, MedTech developers, healthcare professionals, hospitals, patients, policymakers, and more. The ways in which those stakeholders collaborate involve choices that shape (and are shaped by) the expected outcomes (Jasanoff & Kim, 2009), the relationships among stakeholders (Hogervorst et al., 2023; Wehrens, 2014), the desired level of integration between viewpoints (Barben, 2008; Gauvin et al., 2010; Klenk & Meehan, 2015), and what is considered 'real' knowledge (Gunn, 2023; May, 2013). Moreover, futureproofing governance typically raises questions about who is invited to participate to construct a future and whose expectations count (Barben, 2008; Guston, 2008). Still, if the future is indeed now, then now would also be the time for experts to decide how to work together to produce, control, or avoid the future(s).

A Brief History Of The Future

To situate current ways of thinking about the future in MedTech governance, I will zoom out for a very succinct (and necessarily incomplete) 'History of the future'. The future has long been seen as a continuation of the present, over which individuals had little control, predetermined by fate or divine will and the cyclical rhythms of agriculture (Andersson, 2018; Visser, 2024; White, 2024). When discussing the history of the future in the Western world, authors often point to the Enlightenment as a time when thinking about the future changed. Beginning in the seventeenth century, new political traditions and ideas about knowledge changed this anticipatory stance. The future was henceforward seen as open and uncertain, but malleable to human intervention.

Modern medicine also has its origins in this period, with the idea that humans could change their fate through knowledge and effort (Porter, 1999). Thinking about the future and technological progress often goes hand in hand. As technology advanced from the Industrial Revolution in the 18th century onward, more and more technologies were developed, including in the field of medicine. This enabled advances in MedTech. Examples include vaccines, the stethoscope, or X-ray imaging. These developments were accompanied by increasing government intervention. The urbanization that followed the Industrial Revolution led to ideas about public health and government responsibility, further strengthened by advances in vaccines and antiseptics. The idea grew that technology could be managed for the public good, using increasingly standardized methods.

Since the early 20th century, government agencies have emerged across the Western world to manage the uncertainties of innovative technologies (White, 2024). By the late 20th century, Health Technology Assessment (HTA) agencies like ZIN were becoming key players in governing health technologies, reflecting broader ideas about the role of government—from paternalistic protection to market-driven efficiency (O'Donnell et al., 2009). Advances in statistics and digital technologies further shaped regulatory approaches, with computers increasingly used to manage uncertainty (Cugurullo & Xu, 2024). These shifts have influenced moral and normative views on government responsibility and the public good, shaping how MedTech is governed. This gave rise to a rather technocratic anticipatory governance, where predictive technologies are used to extend governance into the future (Cugurullo & Xu, 2024; Visser, 2024).

Since the 21st century, however, a new anticipatory stance appears to be emerging in the western world. Currently, and also yet again, the future feels increasingly out of our control, due to various crises, large-scale transitions, and adaptive technologies such as artificial intelligence (AI). Climate change is now widely acknowledged, yet remains

highly politicized, AI's rapid development makes it feel too close to be contained, and the experience of the COVID-19 pandemic has reinforced a sense of unpredictability (Visser, 2024). Rather than opening up, the future seems to be closing in (White, 2024). There is also growing recognition that technological developments have far-reaching implications, necessitating assessments of ethical, organizational, and social dimensions, beyond clinical and economic ones. For instance, CRISPR technologies have raised profound ethical questions about gene editing (Mulvihill et al., 2017). This dual reality has created a tension in governance. On the one hand, there is a call to adopt a broader, more long-term perspective that considers the deeper implications of emerging technologies. On the other hand, ongoing crises have intensified a short-term focus, leading to increasingly reactive and fragmented governance approaches. The future is now.

Futureproofing MedTech governance through anticipatory practices

Because of the complexity of current crises, transitions and technologies, policy reports increasingly call on a diverse group of experts and the public, to integrate the knowledge of different stakeholders (Bruins, 2019; Rathenau, 2022; Zorginstituut, 2020b). Policy tools once designed to shape the future must now be broadened to tame it. This means that policy instruments need to be adapted and broadened towards multidisciplinary purposes, integrating a wider range of perspectives, a longer time horizon, and encompassing more factors, including ethics, social impacts, or sustainability factors. Illustrative of this development is the recent update of the formal HTA definition, with one of the guiding principles for its update being a more explicit reference to the *multidisciplinary* nature of HTA (O'Rourke et al., 2020). Also, the aforementioned ZIN and NZA report on Appropriate Care states that "appropriate care is a broader concept than its predecessor, 'Appropriate Use', and now encompasses the organization of care, collaboration between professionals, and the relationship with other domains [...] because we believe that health care must also be futureproof" (Zorginstituut, 2020b, p. 20). The aforementioned Gupta report similarly argues that "now is the time to broaden our perspective" (Gupta, 2022, p. 5).

It would seem, then, that an increasing sense of unpredictability or uncertainty about the future has increased the call for futureproofing governance of healthcare, including for innovative MedTech. In response, there is a proliferation of anticipatory practices that aim to anticipate and manage the impact of MedTech despite uncertainty, with collaboration among diverse stakeholders as a critical component. Examples include international horizon scanning policy instruments, to know sooner what is 'coming to market' in order to prepare governance processes more effectively (Oortwijn et al., 2018). Another example is the proliferation of HTA of MedTech (IJzerman et al., 2017), institutionalized in the recently adopted HTA regulation which mandates EU-wide

assessment of certain MedTech innovations in risk classes II and III from 2025 onwards (EU, 2021b). Yet another example of anticipatory practices are early dialogues between HTA agencies and MedTech industry, to identify risks earlier and help guide industry (Blankart et al., 2021). More informal anticipatory practices exist as well, that engage with the future and uncertainties in the present through less standardized processes (Muiderman et al., 2020), examples including making informal calls or attending information events (Orsato et al., 2017).

Overall, the goal of these anticipatory practices seems to be to 'know more, sooner, together', in order to reduce uncertainties for decision-making around market introduction and reimbursement. This raises important questions: Who is invited to participate in these forward-looking efforts, and who is excluded? How do the actors involved navigate these calls to futureproof MedTech governance? And how do they anticipate and prepare for a future shaped by technologies that have yet to be developed? This dissertation delves into such pressing questions. I explicitly do not intend to give a comprehensive evaluation of the entire MedTech governance system. Instead, I focus on the day-to-day practices of developing, implementing and executing MedTech governance, by following and analyzing several anticipatory practices, in the context of HTA and HTA agencies. I analyze such practices through a theoretical framework of anticipatory governance and boundary work, which I will elaborate on in the next section.

Conceptual lens: Anticipatory governance and boundary work

Anticipatory governance is one of the ways in which a futureproof or prospective approach to governance is theorized in academic literature. The concept originates from diverse literatures, including science and technology studies (STS) (e.g., Barben, 2008), sustainability studies (e.g., Boyd et al., 2015), futures studies (e.g., Fuerth & Bezold, 2009), and public administration (e.g., Chi, 2008). As a concept, it has been applied to the governance of a wide range of emerging technologies (Fisher et al., 2012; Nelson et al., 2021; Ozdemir et al., 2011), as well as the governance of environmental sustainability (Dolez et al., 2019; Muiderman et al., 2022). Overall, the concept seems useful in areas characterized by uncertain futures, multiple actors involved in the governance of those futures, and potentially high risks associated with failure to act in the present.

In the process of developing this dissertation, I came across the concept of anticipatory governance rather inductively. More and more, this literature emerged as a productive way to analyze MedTech governance from multiple angles. Two overarching angles can be distinguished in the literature: anticipatory governance is used either as a more descriptive, *conceptual* framework, analyzing how anticipation is used to deal with uncertain futures, or as a more prescriptive, *normative* framework, advocating how

emerging technologies should be governed. I engage with both uses of the concept in this dissertation, as both help shed light on our data. I will elaborate shortly on both approaches below.

Conceptual approaches to anticipatory governance

In more conceptual approaches in the anticipatory governance literature, the researcher is invited to analyze how the future is framed and what this means for actions in the present. Methods of engaging with the future are termed anticipatory practices. Anticipatory practices enact the future in specific ways, embodying how the future is anticipated. HTA and horizon scanning are examples of more formal or institutionalized anticipatory practices, with other examples including vision exercises, sandboxes, or road mapping (Muiderman et al., 2020). Other anticipatory practices are more localized and temporary, such as making informal calls, attending events or choosing in which journal to publish an article (Alvial-Palavicino & Konrad, 2019).

The different stakeholders involved in anticipatory practices may hold different expectations of the future or ideas for what this means for actions in the present. For example, 'regulatory sandboxes' are increasingly used in MedTech governance as a controlled environment for experimentation (Elvidge et al., 2024; Yordanova, 2024), but the private and public actors involved may have different ideas about the purpose of such sandboxes, for instance on how to deal with uncertainties around innovation and safety (Buocz et al., 2023). Some expectations of the future may be more prominent or dominant than others. Because decisions on the direction and scope of anticipatory practices need to be made eventually, notions of politics become important (Brown, 2014). Here, I refer to "politics" as the everyday negotiations, power dynamics, and discursive practices within and between institutions and stakeholders, rather than formal, state-level or electoral politics. This begs the question of who is invited to anticipatory practices, whose expectations of the future are more dominant, and how decisions between competing expectations are made.

The way in which the future is envisioned can also differ. Some anticipatory practices are more attuned to technocratic government needs, typically representing the future in a more linear and deterministic matter, aiming to provide usable information to reduce uncertainties. Other anticipatory practices intentionally have a more pluralistic approach, in other words, they suggest multiple possible futures and point to inherent uncertainties, that are to be engaged with rather than reduced (Barben, 2008). Yet others are more reflexive and critical of the ways in which the future may be used to legitimize certain actions in the present. Muiderman et al. (2020) have distinguished four conceptual ways of how anticipatory practices use anticipation to deal with uncertain

futures, i.e., (1) to predict the future; (2) to build capacity for the most plausible future; (3) to collectively imagine diverse futures; and (4) to critically reflect on anticipatory practices (see figure 1).

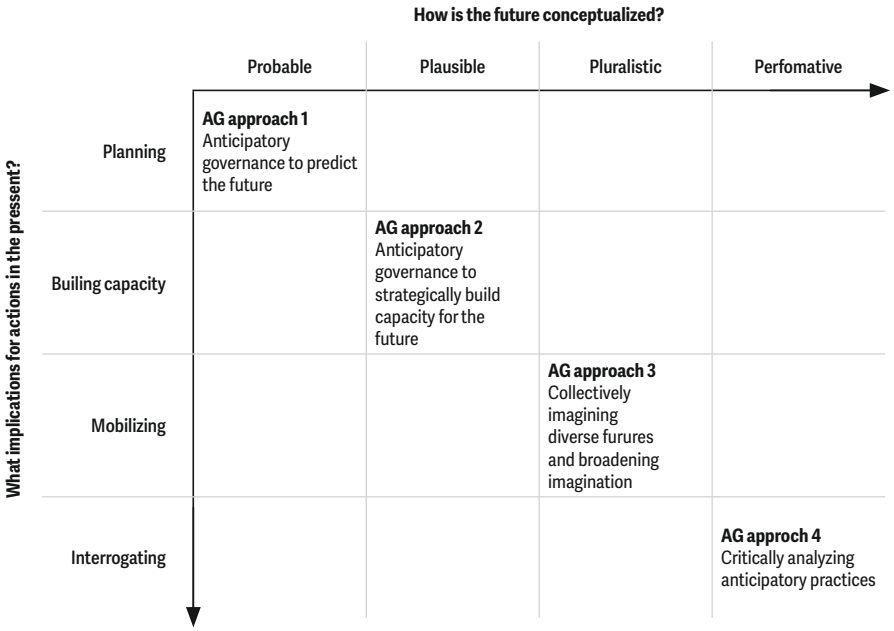

Figure 1: Conceptual framework: 4 approaches to anticipatory governance. AG = Anticipatory Governance

As a conceptual framework, anticipatory governance has been applied most often in the context of critical reflection on climate governance. Such applications highlight how predictive anticipatory practices are generally privileged over deliberative or pluralistic approaches (Gupta et al., 2020; Muiderman et al., 2023; Muiderman et al., 2022). Literature also calls for further reflection on the relationship between public and expert knowledge in anticipatory climate governance and on how to open up discussions and decisions to a wider range of stakeholders, rather than privileging already powerful voices (Davies & Selin, 2012). In addition, literature discusses how anticipatory climate governance is largely dependent on Western funding and international collaboration is often presented as apolitical (Muiderman, 2022). Finally, scholars warn how certain framings of the future can be performative in justifying actions in the present, e.g., framing something as a climate 'emergency' could justify more far-reaching actions in the present (Gupta et al., 2020; Muiderman et al., 2020). In this dissertation I explore a similar conceptual application of anticipatory governance in the context of MedTech governance. As I show, anticipatory practices play a significant role within the domain

of MedTech governance. Examining such governance through the lens of anticipatory governance thus provides an important addition to the broader body of conceptual anticipatory governance literature.

Normative approaches to anticipatory governance

Literature that engages with anticipatory governance as a more normative framework, on the other hand, prescribes how the future could or should be governed. This approach is particularly common in the context of technology governance (Lysaght, 2022; Nelson et al., 2022; Nelson et al., 2021; Ozdemir et al., 2011). Within more normative approaches, anticipatory governance is posited as a solution to the difficulties of innovation governance, alluding to the aforementioned friction between innovation and governance. The more normative angle in anticipatory governance literature generally prescribes multidisciplinary collaboration in order to jointly address uncertainties by integrating perspectives. This angle in the literature is generally quite hopeful, with scholars stating that "we can shape the future based on foresight combined with practical action" (Fuerth & Bezold, 2009, p. 14) or that anticipatory governance is the "simple solution" to address the difficulties of innovation governance (Guston, 2008, p. 940). It aligns mostly with AG approach 2 (see figure 1).

This application of anticipatory governance seems to have gained ground in discussions around nanotechnologies. As Barben et al. (2008) argue, "the futuristic discourse of nanotechnologies, as well as their fundamental technical and social uncertainties, requires the cultivation of a societal capacity for foresight, by which we mean not only formal methodologies but also more general abilities to bridge the cognitive gap between the present and the future" (p. 991). Apparently, in discussions around nanotechnologies, social scientists were called upon by policymakers to engage with nanotechnologies (Macnaghten et al., 2005). Public resources were made available to include social scientists from the outset, whereas previously such scholars were often not included until after the development and introduction of technologies. Social scientists were asked to help shape innovation processes in line with wider public attitudes, to inform and work with the public to shape a more informed public debate, and to open up the 'black box' of science and innovation so that implicit assumptions shaping technological development can be exposed and reflected upon.

The inclusion of social scientists is a trend that is observed outside of the nanotechnology debate as well. In fact, this dissertation was part of such a multidisciplinary collaboration that intentionally incorporated the social science perspectives, namely the Medical Delta Project. The rationale behind including the social science perspective is formulated as follows: "Medical Delta aims to realize sustainable care with techno-

logical solutions. For innovation to be sustainable, it is important to understand its full impact on society. This includes clinical, financial, organizational, and ethical factors, among others." (MedicalDelta, n.d.) Within this project, this PhD project was part of the sub-program 'the Journey from Prototype to Payment'.

Another example in the Dutch context is the Convergence Project, a collaboration between the EUR, the Erasmus Medical Centre (EMC) and the Technical University of Delft. The aim of the sub-program 'Health & Technology' reads: "[We] are joining forces and integrating knowledge, expertise and methodology. Through convergence, we will form novel frameworks that foster scientific discovery and technological innovation in the field of health and healthcare." (Convergence, n.d.) Other scholars have already reflected on how such an inclusion of social scientists is often quite difficult, partly because of existing hierarchies in knowledge frameworks and between academic disciplines (Gardner, 2012). Literature on anticipatory governance remains however quite hopeful that inclusion can lead to more comprehensive or holistic governance (Zaratin et al., 2022).

Interestingly, the more normative approach to anticipatory governance has its origins in Technology Assessment (TA), which is in turn a precursor to HTA. TA developed in the United States in the 1960s as a reaction against the environmental, health, and societal consequences of the more widespread proliferation of nuclear technologies (Banta, 2003; Leys, 2003). In the early stages, it was posited as a way to anticipate all potential (negative) consequences of a technology from the early stages of development (Leys, 2003). More and more, however, scholars realized that this was a difficult endeavor. Different approaches to TA emerged, with different ways of dealing with predictability. Guston & Sarewitz (2002) distinguish two types of TA: An instrumental approach, "in which the social scientific and policy analytic approaches of experts dominate" (p.96), and a discursive or deliberative approach, in which broader stakeholder engagement is encouraged. HTA seems to have developed more in line with the instrumental approach to TA (see figure 2). This can be partly explained by the development of HTA in the healthcare context in the 1980s and 1990s, during which there was an increasing focus on rising healthcare expenditure, budgetary problems, quality issues and issues of effectiveness. These factors both justified the development of HTA and shaped its focus as a mostly instrumental exercise by scientific experts focusing on quantitative methods (Leys, 2003).

The more discursive approach to TA, on the other hand, seems to have developed into the more normative angle in the anticipatory governance literature. Guston's work provides an interesting insight into this development. In 2002, Guston discusses TA

as a way to "provide an explicit mechanism for observing, critiquing, and influencing social values as they become embedded in innovations" (p. 94). In 2010, 'real-time' TA is posited as "in pursuit of a strategic vision of anticipatory governance" (p. 432), and in 2014, Guston calls anticipatory governance "a recognizable heir to traditional TA. [...] A more sympathetic category of prospective technology assessment [...] that emphasizes the social shaping of technoscience rather than its control" (p. 231). (Guston, 2010, 2014; Guston & Sarewitz, 2002).

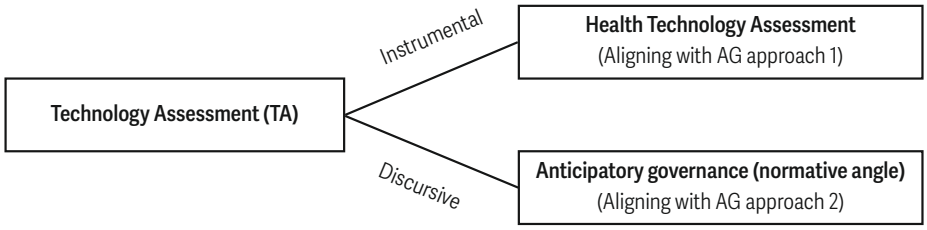

Figure 2: Development of TA into HTA and into the normative approach to anticipatory governance

Boundary work and reflexive space

In my exploration of the more normative angle to anticipatory governance, which generally foregrounds 'deliberation', I follow cases where stakeholders collaborate on MedTech governance, to see how this deliberation plays out in practice. To do so, I draw on boundary work as a sensitizing concept. Gieryn (1983) defined boundary work as efforts to create, defend, and attack boundaries. Others later showed how actors can engage in boundary work to create hybrids around boundaries (Bijker et al., 2009, pp. 147-149). This emphasizes that boundary work is not, as the name might suggest, a strictly exclusionary practice, but rather a constructive process necessary to achieve multi-stakeholder collaboration.

Finally, it seemed that the actors I observed and interviewed were searching for more 'reflexive space' to engage with the uncertainties of anticipatory practices and the necessary boundary work. Here, I draw on 'reflexive space' (Wiig et al., 2021), conceptualized as physical or virtual platforms in which reflexive dialogue can occur, about the challenges, adaptations and needs in daily work practice (p. e1682). They are intentional forums for collective sense-making and critical reflection, that focus on trust-building and dialogue rather than blame and punishment. In the discussion, I reflect further on how and why reflexive spaces might be organized, based on the studies in this dissertation.

Research Aim: Exploring the anticipatory practices of MedTech governance

The research aim of this dissertation is twofold. First, I apply the conceptual lens of anticipatory governance as a guiding lens to the study of MedTech governance and HTA, in practice, to analyze what the increasingly forward-looking focus does at the day-to-day level. To do so, I follow several anticipatory practices, looking at who is (or is not) involved and how their expectations of the future relate to one another. I explore whether there are perhaps more dominant expectations of the future, related to the aforementioned 'conventional means of governance', and how these may affect MedTech governance and HTA. Here, my findings are particularly aimed towards MedTech governance and HTA literature. This is a form of application gap spotting (Sandberg & Alvesson, 2010), as I take a theory from one domain and apply it in a new domain where conceptually, it has not been sufficiently studied before, providing an alternative perspective to further our understanding of the subject matter in question.

Second, I aim to engage with more normative approaches to anticipatory governance. Much of the normative literature on anticipatory governance emphasizes the importance of multistakeholder participation but less is known about how multistakeholder collaboration plays out in practice, especially in the context of MedTech governance. Moreover, the focus of this literature is often on the future, presenting anticipatory governance as a promising approach. Here, I shift the focus to the present, by analyzing what such a deliberative approach does, today. To do so, I make use of literature on boundary work. My aim is thus to analyze empirical case studies of MedTech governance, to see how anticipatory governance plays out in MedTech practices and discourses. These findings are particularly aimed towards the anticipatory governance literature. This is both a form of application gap spotting, as the conceptual approach to anticipatory governance is less developed in the context of MedTech governance than in the context of climate governance, as well as a form of critical confrontation, as I bring a critical perspective to the normative angle of anticipatory governance literature (Sandberg & Alvesson, 2010).

For research aim 1, I thus want to know what literature on MedTech governance and HTA can learn from applying the conceptual anticipatory governance lens, and for research aim 2, I want to know what more normative anticipatory governance literature can learn from case-studies in the context of MedTech governance and HTA. Combining the findings from this twofold aim then enables an answer to the aforementioned, overarching research question posed in this dissertation: How are anticipatory practices shaped by and shaping the governance of MedTech? Answering this question was made possible through a rather unique level of access to the day-to-day levels of MedTech governance, through a collaboration with the Dutch HTA agency ZIN, on which I will elaborate in the next section.

Research setting: The Dutch National Health Care Institute

This PhD project was embedded in an academic collaboration between ZIN and Erasmus University Rotterdam; the Academic Research Network HTA (Academische Werkplaats Verzekerde Zorg, AWVZ). As the polycentric governance of MedTech is layered on different institutional levels, my research also focused on different layers of MedTech governance, i.e., on the role of ZIN, on ZIN in interaction with other national and international stakeholders, and on the expectations of other stakeholders towards ZIN. Being part of the AWVZ collaboration gave me access to ZIN and places where ZIN collaborates with other stakeholders on MedTech governance. On the one hand, ZIN thus provided a useful starting point for the objectives of this dissertation. On the other hand, the complicated role of ZIN within (Dutch) MedTech governance also made it a difficult starting point at times. Many of the discussions about the role of ZIN in MedTech governance were about informal roles or based on expectations of a potential future role. To further understand this, it is first important to understand the formal role of ZIN within the Dutch healthcare system, and how this role has evolved over time.

ZIN's predecessors were the Health Insurance Fund (*Ziekenfondsraad*) from 1949 to 1999 and the Health Insurance Board (*College voor Zorgverzekeringen*, CVZ) from 1999 to 2014 (Helderman et al., 2014). The role of the Health Insurance Fund was to monitor the health insurance fund and to advise the government on health policy. It was established during a time when the government began to take its responsibility for public health increasingly seriously. This institution evolved into the CVZ, which was given a broader role. During this period, the Dutch Health Insurance Act (*Zorgverzekersingswet*, ZWV) came into force, introducing a system of compulsory private health insurance for all Dutch citizens. CVZ was now tasked with managing the contents of the basic benefit package, which constitutes a pre-defined basket for the mandatory health insurance of all citizens. In 2014, this institution was transformed into what is now 'Zorginstituut Nederland' (i.e., ZIN), and its role was expanded further: it is now tasked with 'guaranteeing the quality, affordability and accessibility of health care' in the Netherlands (Zorginstituut, 2024a).

This broadening of the role from *monitoring* to *managing* to *guaranteeing* is in line with ZIN's continuous adaptation to the political-administrative landscape. It also alludes to the balancing act between governance and innovation discussed earlier in this introduction, and the way in which the role of government in relation to innovation is seen over time. Such continuous adaptation is not easy, especially as it often involves balancing the competing interests of different stakeholders. The idea behind ZIN as an independent government agency is that it should be less subject to societal pressures than political leaders, as the independent institute can transcend regular electoral

cycles. Yet research shows that ZIN still needs to be seen as legitimate by citizens, stakeholders and politicians alike, to ensure its longevity (Van de Sande, 2023). Many of my early conversations with people working at ZIN revealed this difficulty of balancing the legitimacy of the institute with not being an angry gatekeeper ("boeman") that rejects MedTech's entry into the basic benefit package. In fact, the political rationale for my PhD project stemmed from ZIN's desire to further explore their complicated role in relation to MedTech.

A number of other historical developments are important as well. The first is how around 2000, political rationale was such that the healthcare market should be given more freedom to innovate, with less regulation (CVZ, 2008). More power was to be given to private health insurers, creating more competitive incentives and market dynamics. The aforementioned ZVW was one of the culminations of this rationale. For MedTech, this also involved a gradual change from a 'product-oriented' evaluation by CVZ of specific MedTech innovations, to an increasingly 'function-oriented' description of MedTech categories, to be evaluated by the health insurer (CVZ, 2008). For example, all MedTech that perform the function of increasing mobility were grouped together, as were all innovations that improved hearing. To achieve this, the function was described uniformly by CVZ at the statutory level, but the insurer was given more freedom to decide which form best meets the needs of the insured. This function-oriented description was intended to facilitate innovation, as similar MedTech innovations could be reimbursed by health insurers without having to wait for CVZ to evaluate each innovation separately.

Together with this development towards a function-oriented description of MedTech, a distinction was made after 2008 between 'MedTech' or 'health-oriented technologies' versus 'wellness-oriented technologies' or 'participation-oriented technologies' (CVZ, 2008). The latter category of technologies is now supervised by the municipalities under the Social Support Act ('Wet Maatschappelijke Ondersteuning', WMO), introduced in 2007. Although problems with categorizing innovations as either health-oriented or participation/wellness-oriented technologies persist to this day (see for example Enzing et al., 2021), the latter category remains largely outside the scope of ZIN. New and innovative medical devices were now to be assessed by the health insurer before being included in the open system of the basic benefit package, by determining whether innovations meet the legal criterion of the "State of Science and Practice" (Stand van de Wetenschap en Praktijk), as defined in the ZVW in 2006 (but continuously updated since then) (Zorginstituut, 2023a). Innovations that do not meet this standard are excluded from reimbursement. These changes essentially meant that the evaluation of MedTech went from a closed system, in which the CVZ advised the Minister on a

positive list to be included, to an open system, where they can enter the basic benefit package without CVZ's (now ZIN's) interference.

A second important development is that with the introduction of the ZVW, the political rationale was such that assessment should follow a more integral assessment framework (CVZ, 2006). This was in line with growing concerns about the affordability of publicly funded health care systems, and the way concerns jeopardize public support for maintaining publicly funded health care systems and shake the pillars of social solidarity that are key to maintaining CVZ/ZIN's legitimacy (Abrishami & Repping, 2019). Hence, a more critical look was taken at what conditions should be attached to the BBP. Driven by the need for a more objective, transparent and systematic approach to health care reimbursement decisions, it was increasingly discussed that decisions should be in line with the principles of evidence-based medicine (CVZ, 2008; RVS, 2006). The ensuing system that remains operative today seems largely based on two reports by the public health council (*Raad voor de Volksgezondheid*, RVS) (RVS, 2006, 2007). In the reports, RVS stated that decisions on MedTech and other health technologies were often influenced by non-transparent decisions, such as media influence and lobbying. To counteract lobbying, hard data like cost-effectiveness analyses were to be preferred (RVS, 2006).

A structured two-phase decision-making process was subsequently introduced in the Netherlands. The first phase, the assessment phase, is based on quantifiable criteria, including necessity (operationalized as disease burden) and effectiveness in relation to costs. This phase determines whether an intervention should be reimbursed in principle. The second phase, the appraisal phase, allows for a social assessment of the initial decision, providing room for considerations beyond the technical evaluation. If the appraisal phase results in a different outcome, this revised decision must be explicitly justified. To ensure the integrity of this process, an authoritative body is tasked with overseeing its proper implementation, called the Advisory Package Committee ('Advies Commissie Pakket' or ACP, consisting of 'societal actors' such as clinicians, health economists and other scientists (Zorginstituut, 2024). As the report by RVS states, such a quantitative model is not without limitations, but it is considered more structured and transparent than purely qualitative approaches (RVS, 2006). Some stakeholders were against the assessment framework because of doubts about the objective measurability of disease burden and because, in their opinion, the CVZ placed one-sided emphasis on evidence-based research. Still, the system was implemented, and in 2008, four package criteria were defined: effectiveness, necessity, cost-effectiveness and feasibility (RVS, 2006).

A third development is a transition from reactive, to risk-based, to proactive package management for MedTech. Due to the focus on costs and pressure on the health care budget around 2006, there was (and still is) growing political rationale that CVZ (or ZIN) should focus on health technologies with the greatest potential burden on collective health care resources and those with the greatest potential for cost-effectiveness gains (RVS, 2006). This commitment is exemplified by the implementation of the lock procedure for expensive pharmaceuticals in 2014. In view of the high costs of expensive pharmaceuticals, it was decided that they should be evaluated by ZIN in a product-oriented manner, on the basis of the four package criteria, before being included in the basic benefit package. To date, ZIN has not developed a closed system for expensive MedTech, and other decision-makers remain responsible for their evaluation. Health insurers are responsible for the inclusion of so-called "extramural MedTech" in the basic benefit package (or in a separate, supplementary package, which can differ per health insurer). In the case of intramural MedTech, i.e. MedTech that is used within the hospital, it is up to healthcare professionals and hospital administrators to decide whether to invest in MedTech. ZIN intervenes in a risk-based manner, namely when it receives a signal from the field (i.e., health insurers, patients, or the NZA) that an innovation poses a risk to the publicly funded system. In such cases, ZIN evaluates MedTech and publishes an indication report (*'duiding'*).

The last reactive, product-oriented advice for MedTech by CVZ was published in 2013. Since 2014, ZIN has published several risk-based position papers (*'standpunten'*) on MedTech innovations, e.g., for real-time continuous glucose monitoring (Zorginstituut, 2018) or transcatheter aortic valve replacement (Zorginstituut, 2020c). There are several factors that complicate this risk-based, open system for MedTech. Health insurers tend to make decisions over a shorter time horizon, potentially disadvantaging MedTech that improve quality, accessibility or affordability over a longer time horizon (Enzing et al., 2021). Health insurers also seem even more vulnerable to negative publicity and reputational damage, because of free provider choice, which limits stricter purchasing agreements (Maarse & Jeurissen, 2024). In addition, healthcare professionals' decision to adopt MedTech is characterized by additional parameters than the ones defined under the 'Stand van de Wetenschap en Praktijk' (e.g., 'affordances'; Abrishami et al., 2014), which are not always in line with ZIN's mandate of ensuring the affordability, quality and accessibility of health care for all Dutch citizens. For example, the adoption of cutting-edge technologies is a sign of clinical excellence, and it is important for hospitals' competitive position to be at the forefront of innovation.

Finally, ZIN increasingly operates within an international regime, with changing international expectations of the role of HTA agencies. One example is that with the

introduction of the aforementioned HTA regulation, HTA agencies in Europe are now expected to conduct joint clinical assessment (JCA) of a number of pharmaceutical and high-risk MedTech innovations (EU, 2021b). In line with international developments, ZIN is contemplating whether they should move from their current way of acting towards MedTech to a more *proactive* strategy. ZIN seems to be searching for ways to define what a more proactive role could or should be, with the anticipatory practices in this dissertation illustrative of ways in which ZIN tries to (re)define a more proactive role in MedTech governance.

HTA agencies in general must act in an increasingly myopic environment, facing greater uncertainty and limited evidence. Good governance stipulates that HTA agencies must act in a consistent and predictable way, which lends itself to the risk-averse use of established, familiar methods (Elvidge et al., 2023). However, these methods are increasingly being broadened and adapted to accommodate new technologies and to proactively engage with future consequences. The data that is available on such new technologies to inform such methodologies are often sparse. To be able to act in a consistent and predictable way, HTA agencies require data to conduct relative effectiveness, however, increasingly health technologies are granted market access based on single arm trials with surrogate outcomes and a relatively short-follow up (HTA-CG, 2024). Other HTA institutes are therefore similarly engaging in anticipatory practices in the context of MedTech governance, such as horizon scanning (Garcia Gonzalez-Moral et al., 2023; Khan et al., 2023; Oortwijn et al., 2018; Ormstad et al., 2023), early dialogues (Backhouse et al., 2011; Blankart et al., 2021; Geisler, 2011; Ibargoyen-Roteta et al., 2022), sandbox approaches (Buocz et al., 2023; Elvidge et al., 2024; Leckenby et al., 2021; Miller & Robson, 2013; Yordanova, 2024), or environmental impact assessment (Greenwood Dufour et al., 2022; Toolan et al., 2023).

Taken together, the above shows that HTA agencies are constantly (re)defining their role and responsibilities. It can be difficult to study the role of an organization when that role is part informal, aspirational, or ambiguous. I was able to explore the complexities and nuances of this balancing act by ZIN through a multi-method and interparadigmatic research approach, which I will elaborate on in the next section.

Research design: Interparadigmatic and transdisciplinary research in(to) MedTech governance

This research grew out of an interest in exploring MedTech governance. There seemed to be a need for further clarification, both from a personal point of view, as described at the beginning of this dissertation, and also from an institutional point of view, where ZIN was facing similar questions regarding its role in managing uncertainty in Med-

Tech innovation. One can take different approaches to investigate this topic. Overall, this dissertation takes an interparadigmatic, mixed-methods, and transdisciplinary approach. Most of the work included in this dissertation follows a qualitative ethnographic approach, in line with the goal of studying MedTech governance in practice. The qualitative case studies are complemented by a discursive analysis of academic literature and by a cost-utility analysis (CUA), a quantitative method. To reflect on the interparadigmatic approach, I also conducted a comparative auto-ethnography of diary entries, together with two other PhD candidates, as a form of deep ethnographic self-reflection. As a whole, I gathered a large collection of data, including field notes based on approximately 900 hours of ethnographic observation, 44 interviews, approximately 100 documents, 1920 articles (in a discourse analysis), and approximately 600 pages of diary entries. Chapters 1-6 detail the specifics of the data and methods used per study. Below, I will briefly introduce the interparadigmatic, mixed-methods, and transdisciplinary elements of my research design.

First, an interparadigmatic approach means that the research covers multiple research paradigms. A research paradigm includes ontology (how reality is constructed) and epistemology (how knowledge about this reality is developed). This thesis predominantly follows a constructivist ontology, which assumes that reality is constructed or socially negotiated, and an interpretive epistemology, which recognizes that knowledge of social reality emerges from the (shared) interpretations of researchers and participants (Ward et al., 2015). This approach was fitting for a study on the governance of MedTech in practice, elucidating how different actors give meaning to such governance. Rather than operationalizing variables a-priori and testing their validity, reliability, and generalizability, I thus generally focused more inductively on how actors make sense of those phenomena in the situated contexts of their work (Schwartz-Shea & Yanow, 2013). Therefore, data collection primarily relied on qualitative research methods: collecting stories from and observations of the actors involved in MedTech governance. In keeping with this approach, I did not attempt to pre-define what "medical technologies" are, but rather approached this as an empirical question, to see how the actors I observed and interviewed themselves gave meaning to MedTech.

The first study in this dissertation, however, fits a different paradigm, following a positivist approach. A positivistic ontology means that an objective world exists independently of human knowledge of it. It is often combined with an empiricist epistemology, which means that knowledge can be objectively measured resulting in evidence (Ward et al., 2015). This first chapter portrays a cost-utility analysis of larotrectinib, an innovative pharmaceutical to treat specific tumors. Cost-utility analysis is an HTA method used to compare the costs and effects (expressed in quality-adjusted life years,

QALYs) of a new treatment to the current standard of care. This paper also forms an important background for understanding anticipatory practices with respect to MedTech, because HTA for pharmaceuticals (implicitly) seems to serve as a blueprint.

HTA is generally considered a positivistic approach, as it relies on empirical methods to evaluate the effectiveness of health technologies (Reuzel & Van Der Wilt, 2000). It assumes that there is an objective reality in which the effectiveness of technologies can be measured and compared across populations. It relies on empirical data from clinical trials or observational studies, which are evaluated using predominantly quantitative methods. From these methods, it seeks evidence-based conclusions to inform decisions about broader populations. Because HTA is often applied within decision-making settings, I would argue that at times it necessarily takes a more pragmatist approach, stipulating that reality is what works in a given context, evaluating knowledge by its usefulness in action (Kaushik & Walsh, 2019). Policymakers must make decisions that consider the full complexity of interventions, asking not just whether technology is effective, but how, for whom, and under what circumstances. The discussion section of the first paper therefore also includes a reflection on the HTA decision-making framework for pharmaceuticals, and how this may be adapted to fit such innovative pharmaceuticals as larotrectinib.

I would characterize this interparadigmatic nature of this dissertation in three ways. First, the inclusion of the cost-utility analysis of the pharmaceutical larotrectinib, and therefore, the acknowledgement of the paradigmatic rationale behind this paper, means that this dissertation covers research across different paradigms. Although I primarily use the findings of the first paper as a prelude to the more interpretive-constructive parts of this dissertation, this warranted more extensive reflection on the intricacies of different research paradigms than would perhaps have been necessary for a strictly mono-paradigmatic dissertation. Second, many of the objects of study, such as MedTech governance and HTA, are fields dominated by a positivistic approach. Much of my research therefore consisted of interpretive social science research conducted within an academic environment more readily associated with a positivistic ontology. In the field of HTA, interpretive social science methods are rather uncommon. Nevertheless, the value of interpretive, qualitative research is emphasized by scholars in the field (Hofmann, 2013; Leys, 2003; Oortwijn & Klein, 2019). Third, coming from a previous work environment in which I predominantly moved in positivistic and pragmatic spaces, to a research group that takes a predominantly constructivist approach, I myself felt "inter" paradigmatic at times, in between different paradigms, not really belonging to any one paradigm in particular. Mixing or moving across paradigms in

academic research is notoriously a complicated endeavor, and is discussed in elaborate detail in chapter 6 of this dissertation.

The findings are also based on a variety of different research methods ('mixed methods'). Most of the research is based on in-depth qualitative case study research using ethnographic methods (chapters 3, 4, and 5). This means that I conducted observations, semi-structured interviews and document analysis in the context of MedTech governance cases. One of the cases also includes a survey study. Overall, I use the cases to highlight the everyday, micro and meso level aspects of MedTech governance and to explore how uncertainties in MedTech governance play out in practice. Whilst the literature seems to discuss shifting paradigms, expanded definitions, and adapted frameworks in MedTech governance (Husereau et al., 2016; O'Rourke et al., 2020; Unsworth et al., 2021), my ethnographic approach was helpful in highlighting what such governance efforts do in practice, and how the stakeholders involved give meaning to MedTech, HTA, and MedTech governance. These methods allowed me to show that contradictions embodied in paradigm shifts are played out at the local level.

Finally, the research is also transdisciplinary, as it originated through the AWVZ and the Medical Delta program. The goal of this transdisciplinary collaboration is to realize the impact of scientific research through the interaction between science and policy (Wehrens et al., 2012). On the one hand, this collaboration provided unique insights, as I was given access to closed meetings, key figures, and the ZIN intranet. I worked one day a week in ZIN's office and closely followed both the start of an international collaboration on horizon scanning for MedTech as well as ZIN's contribution to a funding call on HTA methodology for MedTech. On the other hand, this close and frequent interaction also meant that I had to take methodological steps to maintain my scientific distance, on which I reflect further in the discussion section of this dissertation.

Outline of the book

This book contains 7 more chapters. Chapters 1 to 6 have been written as separate scientific papers. They can therefore be read independently and may have some overlap. Chapter 1 describes a CUA of a pharmaceutical (larotrectinib) that I started in my previous role and completed during my PhD. The remaining chapters focus on anticipatory practices in the context of MedTech governance. Chapter 2 is an analysis of different academic discourses on the institutional role of European HTA agencies in relation to MedTech. Chapters 3 and 4 discuss the complex role of anticipation and uncertainty in such practices. Chapter 3 is a case study of the start of an international horizon-scanning instrument for MedTech by ZIN and institutions from 9 other countries. Chapter 4 zooms in on how MedTech industry actors navigate the increasingly

anticipatory stance in MedTech governance. Chapter 5 discusses a case study of the ZonMw HTA Methodology program, focusing on round 1, which aimed to involve a wider range of experts in the funding of projects that broadened HTA methodologies to MedTech. Chapter 6 reflects on my experiences of doing research into these topics as a transdisciplinary and interparadigmatic researcher, and what such a mixing of different perspectives means for the organization of science. Subsequently, the discussion and conclusion chapters reflect on the findings of this dissertation and their implications for theory and practice.

Table 1: Research question per research paper included in this dissertation

Chapter	Research question	Methodology
1	What is the cost-effectiveness of larotrectinib compared with standard of care in patients with cancer with tropomyosin receptor kinase fusion-positive tumor types in the Netherlands?	Cost-utility analysis Desk research Structured interviews
2	What are the different academic discourses on the role of European HTA agencies in relation to MedTech?	Discourse analysis
3	What micro-regimes of anticipation exist in the expectations of those collaborating on the international HS tool for medical devices? What tensions emerge between these micro-regimes of anticipation? How are expectations shaped and how do they shape the governance of emerging medical technologies?	Document analysis Observation Semi-structured interviews Member checking
4	How do MedTech industry actors navigate the (changing) governance framework of MedTech and how do their anticipatory practices co-construct the anticipatory governance of MedTech?	Document analysis Observation Semi-structured interviews Member checking
5	How do stakeholders involved in the ZonMw HTA methodology program interpret HTA (methodologies) for MedTech, and how do they envision multi-stakeholder collaboration on HTA (methodologies)?	Document analysis Observation Semi-structured interviews Member checking
6	How is transdisciplinary and interparadigmatic (T/I) knowledge produced? How do T/I PhD researchers navigate predominantly monodisciplinary and/ormonoparadigmatic spaces in practice? How do these practices impact the researcher?	Comparative auto-ethnography Diary study

HTA: Health Technology Assessment, MedTech: Medical technology

CHAPTER 1

Prologue: Governing Pharmaceutical Innovation Through Anticipatory Practices

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Economic evaluation of a tumour-agnostic therapy: Dutch economic value of larotrectinib in TRK fusion-positive cancers

Preface

This paper highlights how complications with "conventional means of regulating technologies", as described in the vacancy mentioned at the outset of this dissertation (ESHPM, 2020), are not specific to MedTech, but occur with other types of technologies that do not fit the existing HTA framework. In the case of larotrectinib, EU market access was granted on the basis of a one-arm basket trial. This is a complication for HTA methods, because the evidence available for cost-utility modeling is insufficient. Many assumptions had to be made, which in turn complicated matters for HTA agencies such as ZIN. In the end, the below cost-effectiveness of larotrectinib was not taken into account by ZIN when evaluating larotrectinib, because there were too many uncertainties (Zorginstituut, 2024b). Instead, ZIN opted for a conditional reimbursement framework. Ultimately, this conditional reimbursement process resulted in the inclusion of larotrectinib in the BBP (Zorginstituut, 2024b). Ultimately, this case thus demonstrated the potential for anticipatory practices (such as a conditional reimbursement process) to culminate in a reduction of uncertainties, be it in the context of pharmaceutical governance.

Abstract

Background

Larotrectinib is the first tumour-agnostic therapy that has been approved by the European Medicines Agency. Tumour-agnostic therapies are indicated for a multitude of tumour types. The economic models supporting reimbursement submissions of tumour-agnostic therapies are complex because of the multitude of indications per model. Objective The objective of this paper was to evaluate the cost effectiveness of larotrectinib compared with standard of care in patients with cancer with tropomyosin receptor kinase fusion-positive tumour types in the Netherlands.

Methods

A previously constructed cost-effectiveness model with a partitioned survival approach was adapted to the Dutch setting, simulating costs and efects of treatment in patients with tropomyosin receptor kinase fusion-positive cancer. The cost-effectiveness model conducts a naïve comparison of larotrectinib to a weighted comparator standard-of-

care arm. Dutch specific resource use and costs were implemented and inflated to reflect 2019 euros. The analysis includes a lifetime horizon and a societal perspective.

Results

Larotrectinib versus Dutch standard of care resulted in 5.61 incremental (QALYs) and €232,260 incremental costs, leading to an incremental cost-effectiveness ratio of €41,424/QALY. The probabilistic sensitivity analysis reveals a 88% chance of larotrectinib being cost effective compared with the pooled comparator standard-of-care arm at the applicable €80,000/ QALY willingness-to-pay threshold in the Netherlands.

Conclusions

The incremental cost-effectiveness ratio was well below the applicable threshold for diseases with a high burden of disease in the Netherlands (€80,000). At this threshold, larotrectinib was estimated to be a cost-effective treatment for patients with tropomyosin receptor kinase fusion-positive cancer compared with current standard of care in the Netherlands.

Key Points for Decision Makers
This is the first ever cost-effectiveness analysis of a tumour-agnostic therapy to be conducted for the Netherlands. The analysis was performed from a full societal perspective, including indirect medical costs, productivity costs and costs for informal care.
Tumour-agnostic indications require modelling across multiple tumour localisations, each with their own parameters, assumptions and uncertainties. This paper discusses the complexities of modelling cost effectiveness for tumour-agnostic therapies.
Larotrectinib was estimated to be a cost-effective treatment for patients with tropomyosin receptor kinase fusion-positive cancer compared with current standard of care in the Netherlands.

1. Introduction

Larotrectinib is the first tumour-agnostic therapy that has been approved by the European Medicines Agency (EMA). Larotrectinib is registered as monotherapy for the treatment of adult and paediatric patients with solid tumours that display a neurotrophic Tyrosine Receptor Kinase (*NTRK*)- gene fusion, who have a disease that is locally advanced, metastatic, or where surgical resection is likely to result in severe morbidity and who have no satisfactory treatment options (EMA, 2019). *NTRK* gene fusions have been shown to be oncogenic drivers (Mateo et al., 2018; Yates et al., 2018), and are responsible for tumour growth, regardless of cancer type. The different cancer types are heterogeneous apart from one important similarity: the *NTRK* gene fusion. The target of action for larotrectinib is the TRK family of proteins including TRKA, TRKB, and TRKC, which are encoded by the *NTRK1*, *NTRK2* and *NTRK3* genes, respectively. Larotrectinib was studied in several basket trials (EMA, 2019). A basket trial's population consists of patients with the same genomic mutation or biomarker who all receive the same treatment. Basket trials generally do not include a comparator arm.

Tumour-agnostic therapies bring forward a new, promising way to treat cancer. However, challenges exist in terms of how these therapies are assessed for effectiveness, cost-effectiveness and, subsequently, reimbursement. Tumour-agnostic drugs are indicated for a multitude of cancer types, as long as they express the mutation. Historically speaking, oncological medication has always been assessed on a cancer-specific basis and not based on the underlying mutation occurring in almost all cancer types. Moreover, although in some rare cancers the incidence of *NTRK* fusions is high, in common cancers the incidence is very low (0.5%), meaning that clinical evidence informing reimbursement decisions for tumour-agnostic drugs is based on studies with small sample sizes, usually without a control group, and the patient population across the different tumour localizations and line of therapy are heterogenous. This makes it difficult to assess whether the drug will provide value for money against standard of care (SoC), as a directly comparable SoC currently does not exist. Namely, current treatment is still cancer-specific and not pan-agnostic solely based on an underlying mutation (Cooper et al., 2020). Moreover, the economic models supporting reimbursement submissions are complex, facing challenges in terms of e.g., model structure, choice for comparator(s) and clinical inputs.

The aim of this study was to assess the cost-effectiveness of larotrectinib in the Netherlands in the registered indication, from a societal perspective (Zorginstituut, 2016). Furthermore, a description is given of key reimbursement challenges for tumour-agnostic therapies in general, and larotrectinib in particular. This is the first cost effective-

ness model (CEM) evaluating a tumour-agnostic indication from a societal perspective, using a weighted combination of different cancer types in the comparator arm. These include breast, colorectal, melanoma, non-small cell lung cancer (NSCLC), one location gathering all paediatric tumours, pancreas, primary CNS, salivary gland, small cell lung cancer (SLCL), and thyroid cancer. Various assumptions were necessary to estimate the cost-effectiveness, as will be described in this paper.

2. Methods

2.1 Model structure

A global economic model was adapted to the Dutch setting to estimate lifetime outcomes associated with larotrectinib treatment or with Dutch SoC in the population of interest (Briggs et al., 2022; NICE, 2020). The economic model is a cohort state-transition model with a partitioned survival approach. This technique is commonly used in late stage/metastatic oncology modelling, and is appropriate for capturing progressive, chronic conditions which are described with clinical outcomes requiring an ongoing, time-dependent risk, such as progression and death. The model includes three health states: progression free disease (PFS), progressive disease (PS) and death. In the intervention arm, patients progress through health states based on outputs from the single arm larotrectinib basket trials (EMA, 2019). For modelling survival in the weighted comparator SoC arm, efficacy inputs from naïve comparisons based on a targeted review of the literature for each of the 10 comparators that are included as SoC (i.e. eight adult tumour locations and one location gathering all paediatric tumours) were considered. These werethen weighted based on the distribution of patients across the tumour locations according to Dutch epidemiology data (Table 3), to form one weighted comparator arm. (Figure 1) The model uses a 7-day cycle length (1-week), capturing the varying treatment patterns and differences in survival of the numerous comparators that are included within the model (SoC treatment specific to each tumour location). Health outcomes and costs are accrued and summed for each arm of the economic model.

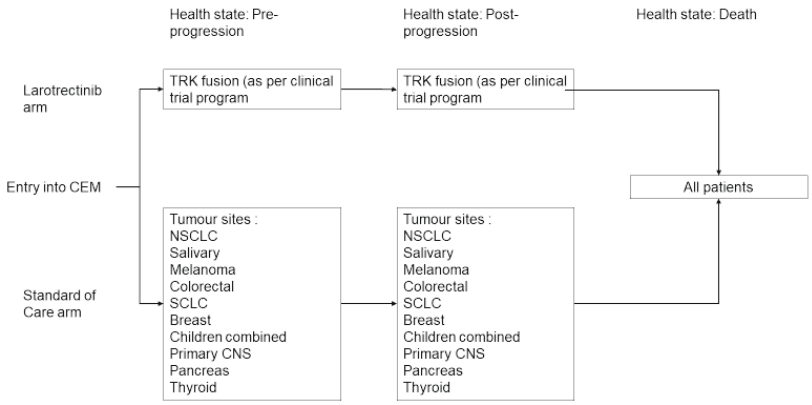


Figure 3: Schematic structure of the model

Both the larotrectinib and SoC arms of the model follow the same health states. However, health states are stratified by tumour site to account for differences in conventional SoC across tumour sites in the SoC arm. This means that the intervention arm is based on efficacy inputs from the pooled analysis of the larotrectinib clinical trial program and cost elements associated with larotrectinib treatment and the SoC arm is based on cost and efficacy inputs per tumour localization.

The model estimates the cost effectiveness over a lifetime period. A time horizon of 80 years was implemented in order to ensure enough weekly cycles (i.e., 4,159 weekly cycles) to accommodate at least 99% of patients modelled in each treatment arm to eventually transition into the 'death' health state. This approach is considered appropriate, given that larotrectinib is associated with reduced mortality and expected long-term survivors and the model deals with paediatric patients which could remain in the model over a long time period. These data cannot be acquired directly from the clinical studies (EMA, 2019); hence a combination of clinical data and model extrapolations were required. For more information on this extrapolation method, please refer to supplementary appendix 2.

2.2 Study population and comparators

The patient population in the economic model reflects the registered EMA indication: adult and paediatric patients with solid tumours that display a *NTRK* gene fusion, who have a disease that is locally advanced, metastatic, or where surgical resection is likely to result in severe morbidity and who have no satisfactory treatment options (EMA, 2019). For the larotrectinib arm, this is the pooled analysis of two analysis sets: the analysis sets in solid tumours excluding primary CNS tumours (n=93), describing

non-central nervous system primary tumours, and the analysis set in solid tumours including primary CNS tumours (n=9), describing central nervous system primary tumours. Together these analysis sets make up n=102 patients. This is the same pooled data on which EMA authorization was based. The baseline characteristics of these patients are presented in Supplementary appendix 1. The mean age was 5 years old for children and 53 years old for adults. Overall, 53% of patients were male (based on the clinical trial population). Furthermore, 19.6% had locally advanced disease and 75.5% had metastatic disease. In addition, 46% had ECOG status 0, 43% had ECOG status 1 and 11% had ECOG status 3. Patients enrolled in the larotrectinib clinical trial program were heavily pre-treated (79.5% of patients receiving ≥1 and 32% patients receiving >3 prior systemic therapies). Approximately 20% of patients were enrolled who had not failed previous therapies but did not qualify for conventional therapy. For example, where the patient's disease stage or severity (i.e., risk of amputation) would have rendered approved therapies ineffective (EMA, 2019).

In the model, larotrectinib is compared with a weighted SoC arm consisting of various tumour localizations (colorectal, NSCLC, melanoma, primary CNS, thyroid, SLCL, breast, pancreas, salivary gland, and paediatric). Note that the clinical trial program included more than 15 different cancer types. However, cancer types from the clinical trial program of larotrectinib of which less than 3 patients are expected per year in the Netherlands, are excluded from the CEM. The excluded tumour localizations comprise cholangio-carcinoma, soft tissue sarcomas (including bone sarcomas; in adults), appendix cancer and gastro-intestinal stromal tumour. Although the weighting according to the tumour localizations from the larotrectinib clinical trial program was not fully in accordance with the weighting found in Dutch clinical practice, it is used in the base case analysis, as it reflects the weighting that informs the clinical efficacy and safety of larotrectinib (Table 1). A scenario analysis has been included in which the weighting of the SoC arm is based on Dutch clinical practice. The rate of tropomyosin receptor kinase fusion positive (TRK+) tumour per cancer type was based on a systematic literature review (Forsythe et al., 2020).

Table 2: Weighting of patients per tumour location

	No. of TRK+ patients (clinical study program)	Weighting of tumour locations (according to clinical study program)	Frequency of NTRK gene fusions in selected tumor histologies (Forsythe et al., 2020)
NSCLC	6	7%	0.17%
Salivary	17	20%	11.11*-79.68[†]%
Melanoma	6	7%	0.31%
Colorectal	6	7%	0.26%
SCLC	1	1%	Not available
Breast	1	1%	0.10[§]-92.87[¶]%
Children combined	34	41%	Not available combined
Primary CNS	3	4%	0.99**-21.21%
Pancreas	1	1%	0.31%
Thyroid	9	11%	22.22[§§]-25.93[¶¶]%
Total	84	100%	

*secretory, [†]acinic cell carcinoma, [§]secretory, [¶]invasive, **glioma, [††]high-grade glioma, [§§]differentiated, [¶¶]papillary

Evidence presented for the weighted comparator arm reflects Dutch SoC in the same line of treatment as the expected positioning of larotrectinib in the treatment algorithm per tumour localization based on expert opinion. Comparative treatment was chosen based on current guidelines and expert opinion and the expected location of larotrectinib within the treatment algorithm of the tumour localization[1]. These comparators are shown in Table 3 and were validated by clinical experts. The clinical inputs for the comparator arm were sourced from the literature and implemented in the model using the Kaplan Meier survival curves and digitation software (Plot Digitizer v.2.1). For a full description of this method, please see the supplementary appendix 2.

1 Please note that the choice for comparator treatment was validated in an advisory board in May of 2019. Clinical practice and standard of care may have evolved since then. This limitation is acknowledged in the discussion.

Table 3: Current standard of care treatments

Tumour localization	Positioning within treatment pathway	Comparator treatment	Source
NSCLC	First or second-line systemic treatment in patients with a proven *NTRK* gene fusion-positive tumour	Pembrolizumab	(Reck et al., 2016; Reck et al., 2019)
Salivary gland	First-line treatment in patients with a proven *NTRK* gene fusion-positive tumour	cisplatin or vinorelbine	(Airoldi et al., 2001)
Melanoma	Second-line systemic treatment in patients with a proven *NTRK* gene fusion-positive tumour	Chemotherapy*	(Ribas et al., 2015)
Colorectal	Second or third-line systemic treatment in patients with a proven *NTRK* gene fusion-positive tumour	FOLFIRI (Fluorouracil (5-FU), Leucovorin, Irinotecan) +panitumumab	(Peeters et al., 2010)
SCLC	Second-line systemic treatment in patients with a proven *NTRK* gene fusion-positive tumour	Carboplatin + etoposide	(Socinski et al., 2009)
Breast	As early as possible in patients with a proven *NTRK* gene fusion-positive tumour	'Treatment of physician's choice'#	(Cortes et al., 2011)
Children combined	First-line systemic treatment in patients with a proven *NTRK* gene fusion-positive tumour	Best supportive care	(Mascarenhas et al., 2010)
Primary CNS	Second-line systemic treatment in patients with a proven *NTRK* gene fusion-positive tumour	Lomustine	(Batchelor et al., 2013)
Pancreas	First-line treatment in patients with a proven *NTRK* gene fusion-positive tumour	FOLFIRINOX (Fluorouracil (5-FU), Leucovorin, Irinotecan, oxaliplatin)	(Conroy et al., 2011)
Thyroid	Treatment of patients with metastatic thyroid cancer who would be eligible for treatment with a current generation of tyrosine kinase inhibitor for radioactive iodine refractory differentiated thyroid carcinoma and an established *NTRK* gene fusion-positive tumour	Sorafenib	(Brose et al., 2014; Kerst JM, 2016; Lam ET, 2024)

*With costs of dacarbazine. # With costs of docetaxel

2.3 Model Inputs

Treatment costs and effects were evaluated using the societal perspective, as requested by the Dutch healthcare institute (Zorginstituut, 2016). Dutch health related quality of life (HRQoL) inputs and costs (e.g., indirect medical costs, productivity costs, and costs for informal care, etc.) were specific to the Dutch setting. Costs and effects were discounted with 4% and 1.5%, respectively. Further, an expected value of perfect information (EVPI) analysis was implemented. Model inputs were validated by Dutch clinical experts in oncology treatment.

2.3.1 Clinical

For the intervention arm (larotrectinib), the clinical inputs of interest are sourced from the clinical studies in the clinical trial program: LOXO-TRK-14001, SCOUT and NAVIGATE trials (EMA, 2019). Please see the Supplementary appendix 1 for an overview of these studies, the number of patients and the tumour types included. To populate the CEM, parametric curves were fitted to the clinical data from the clinical study. For larotrectinib, the Weibull function was chosen as the most appropriate fit for both PFS and OS, the tables supporting this decision are presented in supplementary appendix 2 (i.e., besides Akaike Information Criteria (AIC), clinical plausibility was considered as well. It was decided to set by default PFS and OS for larotrectinib to Weibull, in order to reflect clinical plausibility and allow change in hazard with aging). The comparison of larotrectinib is made against a comparator arm which consolidates the efficacy inputs for each of the tumour locations. PFS and OS curves specific for each tumour location were fitted and its parameters were fed into the model. The resulting curves were then weighted following the representation of each of the same tumour locations in Dutch epidemiological data. Together they make up one comparator arm, weighted for the various tumour locations. The extrapolated PFS and OS curves for the comparator arm are given in supplementary appendix 2, as well as an overview of efficacy data fed into the model and the data sources.

2.3.2 Utilities

Health-related quality of life (HRQoL) is modelled based on the EQ-5D-5L data from the larotrectinib trial. The Dutch tariff was applied to the utility values (Versteegh et al., 2016). Note that the HRQoL of the children in the SCOUT larotrectinib trial was assessed by means of the Paediatric Quality of Life Inventory (PedsQL). In the absence of a dataset to map the PedsQL to the Dutch EQ-5D tariffs, the Dutch utility values applied in the health economic model are only based on the EQ-5D-5L data collected in the NAVIGATE trial of the adult population.

Table 4. Utility Parameters

Utility value per health state		Country values	Source
PFS	PS		
0.820	0.730	Netherlands	Bayer (analysis of the larotrectinib clinical trial program, adult population)

The CEM also considers the HRQoL impact of adverse events by means of applying disutilities to the included grade 3/4 adverse events (AEs). As is typical for Dutch economic evaluations, it was expected that AEs graded below 3/4 are captured by the utilities associated with the health states. The disutilities for each grade 3/4 adverse event are provided in Table 5 below. To capture the full impact of the adverse events, disutilities are applied to the full modelled cohort within the first cycle for each arm based on the event rates from the relevant clinical trials. The HRQoL impact of AEs are applied in the first cycle of the model, which is a simplistic approach applied because of missing or inconsistent evidence available for the comparators regarding the time to resolution or reversal of AEs.

Table 5: Adverse event disutilities (grade 3/4)

Adverse event	Disutility	Source	Note
Alanine/Aspartate aminotransferase increased	-0.0509		NSCLC
Anaemia	-0.11		
Colitis	-0.047		Nafees - diarrhoea
Diarrhoea	-0.047		Nafees - diarrhoea
Dyspnoea	-0.050		Doyle - dyspnoea
Fatigue	-0.073		NSCLC - fatigue
Febrile neutropenia	-0.090		NSCLC - febrile neutropenia
Leukopenia	-0.090		Assumed same as Neutropenia
Lymphocyte count decreased/lymphopenia	-0.090		
Nausea	-0.048		NSCLC - nausea and vomiting
Neutropenia	-0.090		NSCLC – neutropenia
Pneumonitis	-0.05		
Pulmonary	-0.099		Assumed the same as pulmonary embolism with breast cancer (using a more conservative value from identified sources)
Rash/skin reaction	-0.03		
Stomatitis	-0.047		Assumed same as colitis
Thrombocytopenia	-0.090		NSCLC - neutropenia
Vomiting	-0.048		NSCLC - nausea and vomiting

CLL, Chronic lymphocytic leukaemia; NSCLC, Non-small cell lung cancer

2.3.3 Costs

To model costs and resource use, the following sources were used: Google Scholar, PubMed, and previous Dutch reimbursement submissions, Zorginstituut Nederland (ZIN) costing manual, Nederlandse Zorgautoriteit (NZa) online tariff application or previous NICE submissions. Drug costs in the Netherlands were retrieved from medicijnkosten.nl (VAT excluded). Data applied in previous ZIN submissions was used unless new Dutch specific data had been released since the date of the relevant ZIN submissions. Costs were determined for the year 2019 by using the consumer price index (CPI) available from Statline. Cost components include drug acquisition costs, drug administration costs, healthcare resource utilization costs, end-of-life costs, indirect medical costs, adverse event costs, travel costs, productivity costs and informal care costs. These are discussed in detail in the supplementary appendix 3.

Please note that costs associated with testing for *NTRK*-gene fusions were not included in the cost-effectiveness model for two reasons. Firstly, *NTRK*-gene fusions are tested in a next generation sequencing (NGS) test, based on RNA analysis aimed at identifying mutations for which druggable targets exist or are under investigation. NGS based tests are reimbursed in the Netherlands. As a result of a public debate that started before the introduction of larotrectinib, in July 2021 members of parliament adopted a motion that all patients diagnosed with metastasized cancer should be broadly tested on genetic mutations of the tumor. The increasing need for NGS testing is thus an autonomous trend and unrelated to the introduction of larotrectinib. Secondly, physicians' rationale to request an NGS test is to investigate whether a patient might benefit from any targeted therapy, as NGS tests are designed to map many biomarkers at once, so that the treating physician can make an informed choice about which therapy offers the best opportunities for his patient. Thus, the molecular diagnostic costs to detect the NTRK gene fusion cannot be specifically attributed to treatment with larotrectinib. Overall, diagnostic tests (such as CT scans or biopsies) are not included in the model for both the intervention and the comparator arm.

2.4 Sensitivity analysis

Deterministic sensitivity analyses (DSA) were performed to identify those parameters that exhibit a significant influence on the model results, through varying individual input values and capturing the model results for each new evaluation. The upper and lower estimates were determined based on their 95% confidence intervals (whenever known), based on assumptions (e.g., time horizon or discounting), or assuming a +15% or -15% of the base case values. For an overview of the parameters used in the OWSA, see supplementary appendix 5. In addition, several scenario analyses were performed. These are described in more detail in supplementary appendix 5. Probabilistic sensitiv-

ity analyses (PSA) were performed to assess the variation in results stemming from the uncertainty in each individual model parameter. This process was repeated for 1,000 iterations. The burden of disease was calculated by the proportional shortfall method (Versteegh et al., 2016). The calculated burden of disease was 0.95 corresponding with a threshold of €80,000. The details of parameters and distribution used are provided in the supplementary appendix 5. Finally, an expected value of perfect information analysis at the population level (P-EVPI) was conducted, in line with Dutch guidelines for economic evaluations (Zorginstituut, 2016). The results are provided in supplementary appendix 5.

3. Results

3.1 Base case analyses

An overview of the final survival curve plot is presented in Figure 4 and the results of the base case analyses is given in Table 6. The results indicate that there is a more substantial gain in OS than in PFS. Prior research indicates that this occurs more often (e.g., (Hess et al., 2019). The outcomes of the cost effectiveness model show that the ICER of larotrectinib vs. comparators is €41,424 The incremental QALY gain is 5.61. The incremental costs are €232,260. Cost increases are primarily driven by higher treatment costs of larotrectinib.

Figure 4: Final survival curves

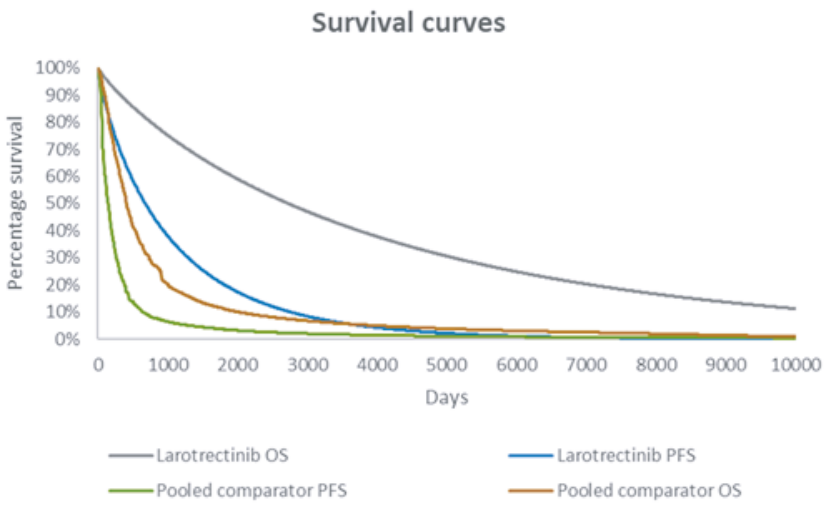


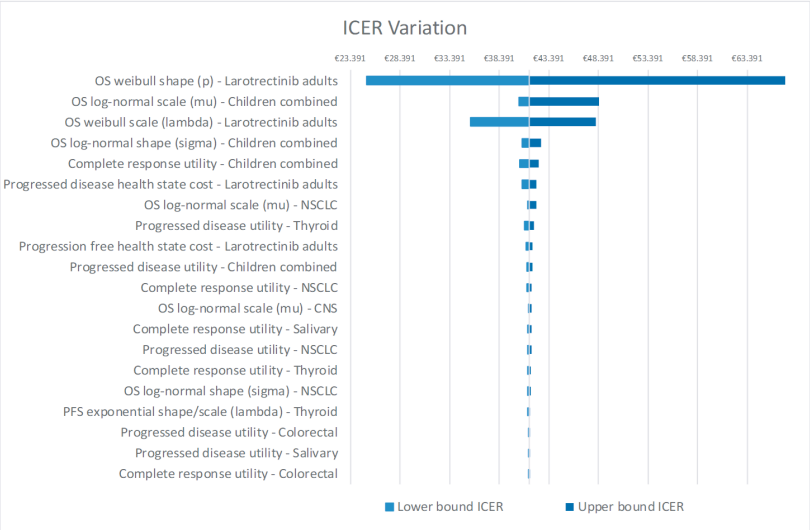
Table 6: Results from the base case analysis

	Larotrectinib	Comparators	Incremental
Life years			
Progression-free	2.97	1.39	1.58
Progressed disease	7,06	1.16	5.91
Total LYs	**10,03**	**2.55**	**7.48**
QALYs			
Progression-free	2.44	1.14	1.30
Progressed disease	5.16	0.84	4.31
Adverse events	-0.01	-0.02	0.00
Total QALYs	**7.41**	**1.97**	**5.61**
Costs			
Progression free survival	€9,484	€2,006	€7,478
Progressive disease	€20,294	€2,2856	€17,438
Death	€576	€380	€196
Adverse event	€228	€600	-€373
Societal cost	€102,682	€30,557	€72,125
Treatment cost	€162,473	€26,772	€135,701
Total costs	**€295,737**	**€63,477**	**€232,260**
ICER (larotrectinib vs. comparators)	**€41,424**		

3.2 Sensitivity analyses

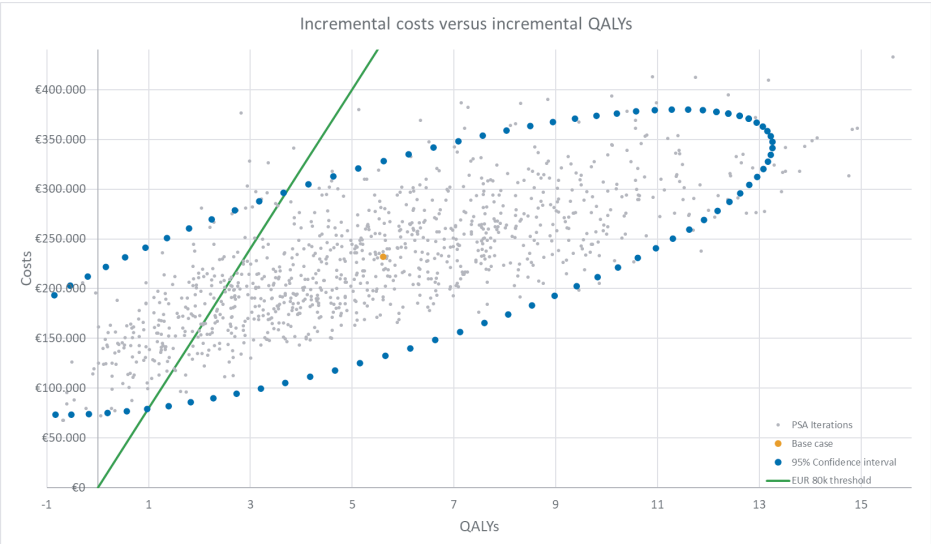
A deterministic sensitivity analysis was performed, the diagram highlights the impact of the 'OS Weibull shape (p) of the larotrectinib adults' parameter, followed by the 'OS Weibull scale (lambda) of the larotrectinib adults' parameter. Apart from the first parameter, the impact of the other parameter variation is limited.

Figure 5: Tornado diagram



The outcomes of the PSA showed that larotrectinib was cost effective 88% of iterations, at a threshold of €80,000 per QALY gained.

Figure 6: CE plane



4. Discussion and conclusion

This paper reports on the cost-effectiveness of larotrectinib, the first approved tumour-agnostic therapy by the EMA. It details a comparison within the Dutch context between costs and effects of the alternative treatments using a partitioned survival model. Larotrectinib vs. the pooled comparator SoC arm resulted in incremental effects of 5.61 QALYs and 7.48 incremental life years, and incremental costs of €232,260, leading to an ICER of €41,424/QALY. The probabilistic sensitivity analysis indicates that larotrectinib is cost effective vs. comparators in 88% of iterations. The gain in life years and quality of life as seen in the cost-effectiveness analysis is considered very high for a last-line oncology treatment. In cost effectiveness studies for orphan drugs, health gains are often high but ICERs are generally less favourable compared to the cost-effectiveness of non-orphan drugs (Chambers et al., 2020). In this case, however, the ICER was less than half of the applicable threshold for diseases with a high burden of disease in the Netherlands (€ 80,000). Larotrectinib is the first tumour-agnostic therapy that has been approved by the EMA.

Note that given the lack of a comparator arm in the pivotal trials and the multiple comparators included in the weighted comparator SoC arm, multiple assumptions were necessary to compute the cost effectiveness analysis. First, the most important assumption is the naïve comparison that is made to the pooled comparator SoC arm, which entailed extraction of PFS and OS information from published data in order to inform the efficacy of the weighted comparator SoC arm in the different tumour locations. Even though the selection of these sources was made with the aim of using a population as similar as possible to the one included in the larotrectinib clinical program, no adjustment for baseline patient characteristics took place. It is recognised that this is a naïve comparison, which is subject to bias. The input parameters are heterogenous and from a wide range of sources. The uncertainty this adds is in part due to the novelty of the tumour-agnostic therapies and the fact that evaluation of these therapies according to standard procedure is difficult. As the field of tumour-agnostic therapies is fast developing, we expect new approaches to be developed. Secondly, the survival data of the patients in the larotrectinib trial was immature resulting in uncertainty. Post-progression survival in the larotrectinib arm was rather high compared to pre-progression which might be explained by the fact that 14% of the patients in the larotrectinib clinical trial program received treatment beyond progression as the treating physician was of the opion that the patient continued to derive clinical benefit. Furthermore, approximately 22% of patients in the larotrectinib clinical trials received post-discontinuation therapy, with 4% receiving radiotherapy and 18% receiving pharmaceutical treatments (EMA, 2019). Thirdly, the choice for comparator treatment was

validated in an advisory board in 2019, clinical practice and standard of care may have evolved since then. Another limitation is that the evidence base for larotrectinib is still evolving. For instance, an intra-patient comparison comparative analysis was published in 2020 (Italiano et al., 2020). This would have been another way to model the efficacy data, however, this evidence was not yet available at the moment of conducting this cost effectiveness analysis. The findings of the intra-patient comparison suggest that larotrectinib improves PFS for patients with TRK fusion cancer compared to prior therapy, with a median Growth modulation index (GMI) of 2.68 in 72 eligible patients and 47 patients (65%) that had a GMI of ≥1.33 (the threshold of meaningful clinical activity) (Italiano et al., 2020). The findings of this intra-patient comparison are in line with the findings of our analysis as both analyses indicate the added therapeutic value of larotrectinib. Finally, the results of the clinical trials used for these analyses are based on low patient numbers without a comparator arm and had a short follow up. Because of the low patient numbers, we decided to exclude tumour types of less than 3 patients per year, as including these patients was deemed too little influential on the CE outcomes. It is important to continue to monitor these patients in practice to see if the safety and efficacy as measures corresponds to the information gathered in the clinical trial program. Nevertheless, given the poor prognosis of patients and promising results of larotrectinib, it is important that evaluation of promising tumour-agnostic therapies such as larotrectinib is organized (van Kempen, 2020).

In terms of modelling, there is considerable uncertainty in the analysis because the tumour-agnostic indication requires modelling across multiple tumour localizations, each with their own parameters, assumptions, and uncertainties. Although necessary to be able to model the cost effectiveness of larotrectinib in these populations, these assumptions form an important limitation to the cost effectiveness model at hand. In addition, the model does not include subsequent treatments for both the larotrectinib and the comparator arm. Although the impact of this modelling decision is expected to be minimal, this is still a limitation to this cost effectiveness analysis. In the Netherlands, we do not expect considerable post-progression treatments, due to the registered indication in which patients are only eligible for larotrectinib in case of no other satisfactory treatment option. Therefore, it was modelled in the fast majority of tumor localizations as last in line treatment.

Lastly, for the weighted comparator SoC arm, we do not specifically use TRK fusion-positive cancers. It is not yet completely understood whether the prognosis of TRK fusion-positive cancers differs from non-TRK fusion-positive cancers. Several analyses suggest that NTRK fusion-positive cancers have a similar or worse prognosis to that of matched patients who do not harbor these fusions suggesting that differences in

prognoses is not driving the higher effectiveness in the larotrectinib arm (Bazhenova et al., 2021; Demetri et al., 2021; Santi et al., 2021).

To our knowledge, this is the first paper that details a cost effectiveness analysis for a tumour-agnostic indication from a societal perspective. The expectation is that quite a few other tumour-agnostic therapies will enter the market in the next decade. Given that tumour-agnostic therapies are a novel phenomenon, there are certain challenges to health economic modelling of these therapies. Several scholars have written about these challenges for tumour-agnostic therapies (e.g., (Hierro et al., 2019; Yan & Zhang, 2018). One challenge is that the basket trials investigating tumour-agnostic therapies' clinical effectiveness are usually small in sample size. This challenge is seen across orphan diseases, and it introduces uncertainty to the clinical data. Furthermore, these basket trials usually do not include a comparator arm. Because the clinical trials are usually single-arm trials, the models need to include a naïve comparison using external comparators from unrelated previously conducted studies. This introduces additional uncertainty to the data population the models. Additionally, the ICER that is presented as an average ICER across indications, may well very per indication. However, because patient numbers are low and naïve comparisons must be made, subgroup analysis is usually not possible. An additional challenge is that health economic models are preferably populated with local, population specific inputs from the country of interest. In the case of tumour-agnostic therapies across multiple indications, daily practice across these different indications may differ substantially per country. This makes it a very time-consuming effort to adapt health economic models to country specific situations. Lastly, because testing strategies will likely differ per country and when compared to the testing strategy in the basket trial, there may be additional differences between the trial population and the population in the countries of interest.

The average response to larotrectinib when compared to regular oncology treatment poses an interesting perspective on this heterogeneity of patients across tumour localizations. Regardless of the treatment under assessment, tumour-specific or pan-tumour, there is always uncertainty. In standard cost effectiveness analysis looking at one tumour localization, heterogeneity still exists in the form of DNA/RNA mutations. In the case of a pan-tumour indication, this heterogeneity is reversed, i.e., not across DNA/RNA mutations but across tumour localization. Given the improved response, it could be argued that the localization type of heterogeneity is less relevant compared to the DNA/RNA type of heterogeneity. More research into this phenomenon is necessary.

It is important that health care decision makers such as Health Technology Assessment (HTA) bodies make sure that their decision framework take into account these

difficulties in order to meet the specific needs for tumour-agnostic therapies. This will hopefully ensure that uncertainties are dealt with properly and allow for new promising agents to arrive faster onto the market. The accelerated approval witnessed for larotrectinib at FDA and the conditional approval at EMA level shows that these therapies are seen as promising. However, as can be seen, clinical evidence supporting them remains challenging when compared to more typical assessments. For example, whereas both the EMA and FDA have decided that high response rate can be considered a proxy for efficacy, HTA bodies usually require endpoints such as survival and quality of life (Cooper et al., 2020). This means that, although medicines may have received EMA and FDA approval, HTA bodies may find the available evidence insufficient to allow for reimbursement. Applying the standard HTA rules to tumour-agnostic therapies might mean local rejection. A pragmatic approach seems inevitable here. A potential solution might be coverage with evidence development, meaning that these therapies will be reimbursed despite the limited available evidence at the moment of entering the market. In the Netherlands, in the absence of an appropriate assessment framework for agnostic therapies, these therapies can momentarily only apply for conditional reimbursement. Larotrectinib is currently conditionally reimbursed in the Netherlands. Main conditions for reimbursement are: an indication committee to check the patient's eligibility to larotrectinib, data collection of the use and outcomes of TRK inhibitors in daily practice and concentration of treatment in a few appointed expert center (VWS, 2021). Other strategies to support these approvals may include post-authorization monitoring, reflecting 'real-world data'. This post-marketing data will be important in measuring the clinical benefit and safety of these new therapies observed in clinical practice. Furthermore, personalised reimbursement schemes in the form of a pay-for-performance structure might be a solution to the uncertainty associated with tumour agnostic therapies. However, here it is important to realize that evidence development on a local level may not always be feasible given the low patient numbers. Therefore, HTA bodies may want to consider developing a joint evidence development strategy together with the manufacturer and the (European) clinical experts.

In conclusion, this paper reports on the cost effectiveness of larotrectinib vs. a pooled SoC comparator, showing that larotrectinib is cost effective vs. the weighted comparators in 88% of iterations. Furthermore, this paper discusses challenges considering market access and reimbursement decisions for tumour-agnostic therapies. It articulates that patient access to these new drugs will depend on opportunities for post authorisation evidence generation and a pragmatic approach by decision makers. Regulatory agencies need to consider the challenges for HTA of tumour-agnostic therapies, to prepare for the inevitable uncertainty associated with the evidence from basket trials, lacking randomization, and pooling across heterogenous populations.

CHAPTER 2

Different Discourses On The Role Of European HTA Agencies In MedTech Governance

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The role of European HTA agencies in governing medical technologies: a systematic literature search and discourse analysis

Abstract

How the role of health technology assessment (HTA) agencies in relation to medical technologies (MedTech) is framed in the literature reflects and influences governance, shaping perceptions and guiding decisions. We identify different academic discourses to advance MedTech policy debates, in light of several factors potentially influencing this role. This is the first time that the role of HTA agencies in relation to MedTech has been reviewed. We conducted a comprehensive search, screened for eligibility, and synthesized findings using discourse analysis. 119 articles were included, from which 5 discourses were constructed. The first discourse describes the HTA agency as an independent evaluator of appropriate evidence for all health technologies. The second discourse explicitly categorizes MedTech as separate from pharmaceuticals and expands the role of evaluator to include encouraging evidence generation for MedTech. The third discourse moves away from the role of independent evaluator and describes the HTA agency as a convener of all stakeholder perspectives, using an experimental approach. The fourth and fifth discourses critically reflect on the role of HTA agencies, the fourth on their level of normative reflection and the fifth on their level of nuanced, clinical expertise. We conclude with recommendations for policy and research.

Keywords

Health Technology Assessment, Discourse analysis, Medical Technology, Government Agencies

Background

Health technology assessment (HTA) agencies play a role in the governance of certain health technologies, their scope varying by country and organizational mandate (Loblova, 2016; Sorenson & Chalkidou, 2012). When it comes to the governance of medical technologies (MedTech), different HTA agencies have different levels of involvement (Basu et al., 2024; Fuchs et al., 2017; Segur-Ferrer et al., 2024). MedTech is defined inconsistently in the academic literature, but typically includes medical devices, digital health, and diagnostics (MedTechEurope, 2022). In most countries, HTA agencies' role in MedTech governance is less established than their role in governing pharmaceuticals (Fuchs et al., 2019; Olberg et al., 2017). However, the role of HTA agencies in MedTech governance seems to be expanding, evidenced, for example, by the rapidly growing number of published HTA reports for medical devices (Ming et al., 2022). This highlights how the role of HTA agencies also evolves over time.

Some of the reasons why the role of HTA agencies may change over time is in response to technological innovation or institutional developments. At the European level, several institutional developments are currently influencing this role. With the introduction of the HTA Regulation (HTAR) (EU, 2021a), HTA agencies in the European Union (EU) are expected to carry out joint clinical assessments (JCA) of certain high-risk medical devices (Tarricone et al., 2020). Other relevant regulations include the Medical Devices Regulation (MDR), the In Vitro Diagnostic Medical Devices Regulation (IVDR), and the Artificial Intelligence (AI) Act (EU, 2017a, 2017b, 2024). It is expected that these regulations will increase the focus on the safety and quality of (certain) MedTech prior to market entry (Wilkinson & van Boxtel, 2019). Although initial reflections seem somewhat disappointed (Hulstaert et al., 2023; Jarman et al., 2021; Shatrov & Blankart, 2022), these developments could increase the amount of evidence available for the assessment of MedTech, which could in turn further amplify European[2] HTA agencies' role in MedTech governance.

Despite this apparent amplifying role for HTA agencies in the governance of (high-risk) MedTech, there is still debate in the academic literature about the applicability of existing HTA approaches to MedTech (Bluher et al., 2019; Enzing et al., 2021). Scholars note that HTA of MedTech is challenging for a number of reasons. Relevant literature reflects for example on the different characteristics of MedTech compared to pharmaceuticals,

2 European countries outside of the EU typically recognize, adopt or closely follow EU regulations in their national or regional standards to facilitate trade within Europe, in addition to independent national regulatory frameworks.

including scarce evidence, incremental or iterative development, and MedTech user learning curves (Cangelosi et al., 2023; Drummond et al., 2009; Fuchs et al., 2017; Fuchs et al., 2019; Tarricone et al., 2017). Scholars discuss how MedTech are often adopted and disseminated before their value has been demonstrated in a standardized manner (Abrishami et al., 2014), partly as a result of their fragmented regulatory system (Fuchs et al., 2017; Olberg et al., 2017). This complicates the role of HTA agencies, for example because it is more difficult to remove products from reimbursement once they are embedded, than to deny reimbursement at market access (Calabro et al., 2018; Haas et al., 2012; Kamaruzaman et al., 2022). These academic discussions give the impression that it may be difficult for HTA agencies to govern (some) MedTech.

Recently, the definition of HTA has been updated (Haji Ali Afzali et al., 2021). In addition to simplifying the language used in the definition, one of the guiding principles for updating the definition was to include explicit reference to the *multidisciplinary* nature of HTA. Although earlier definitions already referred to HTA being performed by interdisciplinary groups, interdisciplinarity was not part of the definition's core sentence. The 2020 update purposefully foregrounded this aspect, starting the definition with 'HTA is a multidisciplinary process', to underline this interdisciplinary nature of HTA, partly as a response to HTA often being defined more narrowly in practice (O'Rourke et al., 2020). Given the expectation of an increasing role for European HTA agencies in the governance of MedTech, the contested nature of the applicability of HTA approaches to MedTech, and the explicit focus on multidisciplinarity in the updated definition of HTA, it would be relevant to understand how the role of European HTA agencies in relation to MedTech is discussed across academic disciplines. The way this role is framed both reflects and influences the governance of technologies, shaping perceptions, legitimizing decisions, and guiding action (Blume, 2009; Burau et al., 2021; Ciani et al., 2016; Nelson et al., 2021).

Literature on the role of HTA agencies tends to focus on pharmaceuticals, as the role of HTA agencies is more established in this context (Ciani & Jommi, 2014; Oortwijn et al., 2010; Shah et al., 2014). An analysis of the framing regarding MedTech could thus be instructive for further understanding and developing the policy framework for MedTech in Europe, by clarifying underlying assumptions that shape assessment practices and regulatory decisions. Therefore, the aim of this paper is to examine how the role of European HTA agencies in relation to MedTech has been framed in academic discourse over time. Taking a historical-discursive perspective allows us to trace shifts in how HTA agencies responsibilities, methods, and institutional positioning are conceptualized. This analysis serves three key audiences: (i) HTA agencies and regulators, who can use the typology as a reflexive tool for rethinking their evolving role in a changing

technological and regulatory landscape; (ii) policy-makers, who require a deeper understanding of why methodological debates surrounding MedTech persist and how they relate to competing visions of HTA agencies purpose; and (iii) researchers, who can use the identified discourses to trace conceptual and normative developments and to better situate their own work within ongoing debates. This is the first time that the role of HTA agencies in relation to MedTech has been reviewed in the academic literature. We answer the following research question: What are the different academic discourses on the role of European HTA agencies in relation to MedTech? To answer this question, we combine a comprehensive literature search and discourse analysis, going beyond a summary of findings to provide an interpretation of the material. We conclude with policy implications and research recommendations.

Methods

Data collection

We conducted a comprehensive search to identify relevant literature. A search string was developed by an experienced information specialist (WB) together with the first author (RM). The search combined terms for medical technology innovations and the name of national and regional HTA agencies in Europe (Box A in Supplementary Materials). The search was limited to articles published in English, and conference abstracts were excluded. No publication date limits were applied, as we aimed to capture the full breadth of relevant literature, including both recent work and the historical development of relevant ideas regarding the role of early HTA agencies. Initially, drug therapies, medicine, and pharmaceuticals were excluded by the search string. However, because of the risk of losing articles that described both innovative MedTech and innovative pharmaceuticals, this part of the search string was removed, and it was decided to manually eliminate those articles that focused solely on pharmaceuticals during the literature selection process. Articles that focused on both pharmaceuticals and MedTech were included. We conducted a search on May 2, 2024, on Embase.com, Medline Ovid, Web of Science, Scopus, CINAHL (EBSCOhost), and One Business (ProQuest) (Bramer et al., 2018; Bramer et al., 2017). We used referencing software (Endnote version X9) to manage the retrieved documents and to remove duplicates (Bramer et al., 2016).

Data analysis

We used a discourse-analytic approach to analyze the selected articles (Hajer & Versteeg, 2005). We followed Hajer & Versteeg's (2005) definition of a discourse as *"an ensemble of ideas, concepts, and categories through which meaning is given to social and physical phenomena, and which is produced and reproduced through an identifiable set of*

practices" (p.300). In our case, we identified the ways in which meaning is given to key concepts including HTA, MedTech, the role of HTA agencies, and evidence. In our case, the set of practices through which meaning is produced and reproduced consisted of writing an academic article, conceptualizing the terms in that article and choosing a journal in which to publish. Although articles could theoretically reflect more than one discourse, we coded at the article level, meaning that each article was assigned to the most dominant discourse in the article. Importantly, inclusion in a discourse does not necessarily imply that an article explicitly endorses that position, but that its framing, assumptions, and interpretive direction are consistent with that discourse.

A central assumption of discourse analysis is that language shapes worldviews. Therefore, metaphors constituted an important part of our analysis. Describing HTA as a "*piecemeal approach*" (Campbell & Knox, 2016) or a "*general toolkit*" (Quentin et al., 2009), or describing the role of HTA agencies as "*forming a bridge between stakeholders*" (Gauvin et al., 2010) or "*starting an assault on Mount Olympus*" (Smith, 1999), are important clues to understand how HTA and the role of HTA agencies is interpreted. What's more, dominant discourses can lead to the exclusion of other, less dominant, discourses (Bröer, 2008), so understanding different discourses and their degree of dominance can be elucidating in understanding policy decisions and how they play out in practice. Notably, an academic discourse differs from an academic theory. Discourses concern shared language to describe phenomena, whereas academic theories concern concepts to explain phenomena. Members of a discourse become trained in the language of a specific set of theories, for example, utilitarianism is a theory on the maximization of health benefits given a limited budget (e.g., (Goetghebeur et al., 2015; Marseille & Kahn, 2019), which could be part of a discourse on health budget distribution.

Our analysis was conducted in phases. First, articles were reviewed for eligibility by the first author (RM). Articles were included according to the criteria listed in Box 1. In cases of doubt, articles were discussed with authors BG and DD. In addition, a subset of 20 articles were blindly co-assessed for eligibility by authors BG and DD, a process that confirmed consistency in inclusion. Snowballing was not part of data collection, however, some articles found in the reference list of included articles were used for further reflection in the discussion section. Then, the first author coded a sample of 20 articles inductively using qualitative analysis software (Atlas.Ti 9.0) (coding list in Box B in Supplementary Materials). After discussing these articles with BG and DD, we drafted a list of coding questions, coding for (1) the interpretation of the role of HTA agencies; (2) the definition and framing of MedTech; (3) narratives around evidence; (4) the responsibilities of and relationships between stakeholders, and (5) relevant metaphors

(Box C in the Supplementary Materials). These were used for a full round of coding, in MS Excel. The authors critically interrogated the analytical themes that emerged from our data until consensus was reached on the characteristics of the discourses. Finally, the number of articles per discourse were counted, as well as the countries discussed within the articles in each discourse and the distribution of the articles across time.

Box 1: Eligibility criteria

An article will be included in the pool of selected articles if its title/abstract meets the following criteria:

a. Title and/or abstract include information on (innovative) medical technologies either in general or one or more than one specific product used in preventive, curative, or rehabilitative care;

b. Title and/or abstract include information on the role, mandate, function, policy, or positioning of national or regional HTA agencies with regards to these technologies. The HTA agencies include those that are part of a national or regional/county government or otherwise legislatively designated independent (non-governmental) agencies in Europe;

Exclusion criteria:

a. Focus on specific HTA methodologies and not on the role of HTA agencies;
b. Focus solely on (innovative) medicinal products/pharmaceutical industry;
    a. If an article focuses on innovative medical technology AND (innovative) drugs/pharmaceutical industry, it will be included;
c. Focus on technologies that are not medical-related (e.g., solely lifestyle, food, or veterinary technologies);
d. Focus on the role of HTA agencies outside of Europe;
e. Focus on hospital based HTAs rather than national HTA agencies.

Whenever the first reviewer is unsure about whether an article qualifies for inclusion, article will also be checked by a second and a third reviewer, and the article's inclusion will be jointly discussed.

Results

In total, 119 articles were included (see Figure 1), from which we constructed 5 discourses. Table 1 shows the distribution of the included articles across discourses. Figure 2 shows the count of articles per discourse over time. We describe each discourse below, elaborating on the conceptualization of HTA, MedTech and evidence, the role of HTA agencies and their relation to other stakeholders. We highlight key journals and describe which countries or regions are discussed within the academic articles belonging to the discourse. Table 1 includes a key metaphor for each discourse. Notably, a large percentage of included articles are about NICE in the United Kingdom (UK) (50%). This is not surprising as NICE is a leading institution in HTA (Sculpher & Palmer, 2020) and articles were restricted to English. We reflect on this finding in our discussion.

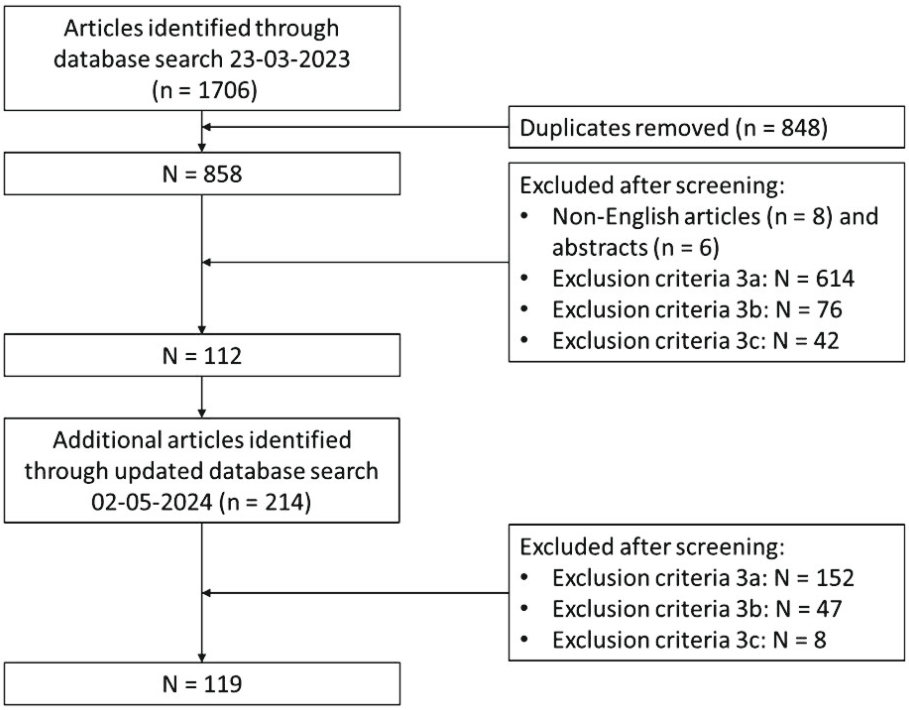

Figure 1: Flowchart

Table 7: Characteristics of the 5 discourses about the role of European HTA agencies in governing medical technology

Discourse	1	2	3	4	5
Role of HTA agencies	Rigorous evaluator	HTA stimulator	Convenor	Criticized: Lacking normative reflection	Criticized: Lacking clinical nuance
Description of HTA	Systematic, rigorous, transparent, efficient, stepwise	Evidence-based, guidance. Often, definition HTA not given.	Multidisciplinary, exploring, broader impact, support	Value-laden, ethical issues, framing	Hurdle, incomplete. Often, definition HTA not given.
Relationship to evidence	Evaluating appropriate evidence	Encouraging better and more mature evidence	Deliberating with stakeholders on best available evidence	Masking underlying issues by focus on scientific evidence	Lacking skills to interpret evidence
Description of MedTech	Not differentiating between health care technologies	Specifically differentiating MedTech from pharmaceuticals OR mentioning specific MedTech (in NICE MTEP)	Mentioning categories (e.g., tests, devices, procedures, programs, digital health, diagnostic technologies, etc.)	Not differentiating between health care technologies	Mentioning specific MedTech (e.g., spinal cord modulation)
Relation to other stakeholders	Independent	Stimulator	Participatory and explorative	Lacking legitimacy	Lacking nuance
Key metaphor	*"Sorting the wheat from the chaff, so that we will know which new treatments should enter mainstream practice immediately.* (34, p. 113).	*"A valuable and necessary compromise between piecemeal decision making by local healthcare providers and conventional HTA, which requires a more mature evidence base."* (25, p.123).	*"This requires a broader, health system perspective, that will need to result in a new, more integrative approach to define and use [...] HTA. It will also require new skills. However, we do not need to reinvent the wheel."* (72, p. 258).	*"The creation of an arm's-length agency [...] may be seen as a manifestation of the technocratic wish, [...] that contentious issues in public life can be resolved by appeal to scientific measures."* (84, p. 718)	*"The vision that doctors will go to work with the British National Formulary in one pocket and a copy of NICE guidelines in the other, (...) reflecting naivety, as (...) guidelines that covered every eventuality would be carried in a wheelbarrow."* (28, p. 824)

HTA: Health Technology Assessment, MedTech: Medical Technology, NICE MTEP: The National Institute for Health and Care Excellence Medical Technologies Evaluation Programme (UK)

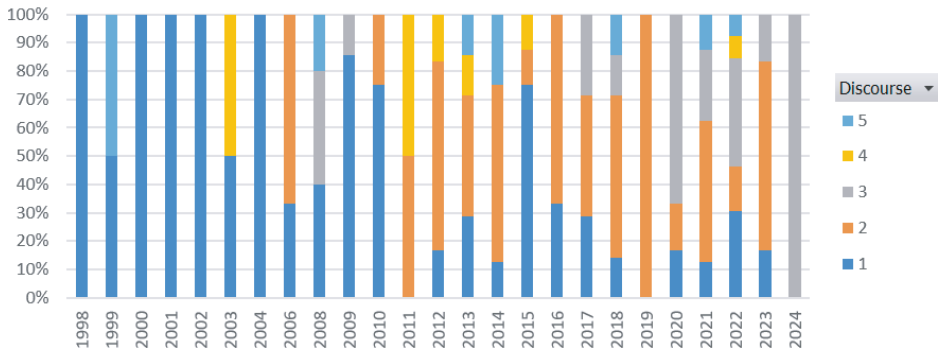

Figure 2: Progression of discourses over time

Discourse 1: The HTA agency as an independent evaluator of all health technologies – sorting the wheat from the chaff

The first, most dominant discourse gives meaning to the role of the HTA agency as a systematic, independent evaluator (Rawlins, 2000; Ritrovato et al., 2015; Specchia et al., 2015), that develops and publishes frameworks and guidelines (Gafni & Birch, 2003). This discourse emphasizes technical expertise (Imaz-Iglesia & Wild, 2022; Marsh et al., 2016) and scientific evidence, often called appropriate evidence (Ciani et al., 2022; Sculpher & Palmer, 2020), robust evidence (Anderson et al., 2022; Quentin et al., 2009), or proper evidence (Sculpher & Claxton, 2010), and contrasted to weak evidence (Ciani et al., 2022). As Table 1 shows, 36% of included articles were categorized into this discourse. Most articles were published in HTA and health economic journals, such as the International Journal of Technology Assessment in Health Care (IJTAHC) (37%), the Journal of Health Economics (9%), Pharmacoeconomics (9%), or Value in Health (7%). Most articles are about Europe (44%, either only discussing Europe or also referencing to institutions outside of Europe within the article) or about the UK, NICE specifically (40%) (see Supplementary Materials). This discourse started the earliest out of all discourses, with the first article we identified as fitting this discourse published in 1998.

HTA is defined as a systematic approach that is rigorous (Ritrovato et al., 2015; Stevens & Milne, 2004) and transparent (Herrmann et al., 2013; Hutton et al., 2008), with the goal of efficient resource allocation (Birch & Gafni, 2002). It is often described in a stepwise manner, referring to routes (Stevens & Milne, 2004) and steps (Ciani et al., 2022), using specific tools (Imaz-Iglesia & Wild, 2022; Neikter et al., 2009). To continue systematically evaluating innovative technologies, HTA methods are seen as ever expanding, by adding new factors, e.g., environmental factors (Marsh et al., 2016; Toolan et al., 2023), or developing new frameworks, e.g., for surrogate endpoints (Ciani et al., 2022), equity weighting (Paulden & McCabe, 2021), or joint assessment (Lo Scalzo et al., 2015). It

is assumed that HTA can be applied regardless of the type of health technology, as this discourse makes no or minimal distinction between different health technologies. Health technologies are often defined within brackets to include pharmaceuticals, devices, diagnostics, procedures, and other interventions. In case authors do give a specific example, these are almost always pharmaceuticals.

In terms of the relationships drawn with other stakeholders, this discourse focused most on HTA agencies alone. When other stakeholders are mentioned, the main ones mentioned are industry and other HTA agencies. Regarding the former, HTA agencies need to ensure that industry bias is removed in order to arrive at neutral evidence (Birch & Gafni, 2002; Toolan et al., 2023). Regarding the latter, this discourse is concerned with harmonization among HTA agencies in Europe (Hutton et al., 2008): Although different healthcare systems mean that the assessment of technologies may lead to different conclusions in different countries, the harmonization and development of identical assessment methods on which decisions are based is seen as achievable, and part of the role of HTA agencies (Hutton et al., 2008).

Discourse 2: The HTA agency as evidence stimulator – evidence as a thorny issue

The second discourse is similar to the first discourse in that the role of the HTA agency is seen as an evaluator of scientific evidence, however, this role is broadened to include a role for stimulating evidence generation'. This seems to be in relation to the fact that this discourse distinguishes more explicitly between pharmaceuticals and MedTech. It adheres to ideas about routes (Crispi et al., 2019; Willits et al., 2014) and robust evidence (Unsworth et al., 2021; Willits et al., 2017), but in applying them more exclusively to MedTech, the framing of the role shifts from a more distanced role of *independently evaluating* technologies to a more involved and proactive role of *guiding* industry, by encouraging adoption (Campbell & Campbell, 2012; Crispi et al., 2019) or promoting uptake of HTA approaches (Campbell, 2011a; Chapman et al., 2014), often by recommending further research (Blankart et al., 2021; Campbell et al., 2017; Tarricone et al., 2020). HTA agencies are seen as not only independently evaluating evidence, but as having a role in ensuring that the evidence is there to begin with. In more recent publications, the focus is on earlier involvement with industry, e.g., throughs early dialogues (Blankart et al., 2021; Hulstaert et al., 2023), to ensure appropriate evidence further down the line. This was the second most dominant discourse, with 34% of included articles belonging to this discourse (Table 1). Most articles were published in more applied journals as well as HTA journals, including Applied Health Economics and Health Policy (35%), IJTAHC (18%), and Heart (8%). Most articles are about the UK (75%) (See Supplementary Materials), often about NICE's 'Medical Technologies Evaluation Programme' (MTEP), which was launched in 2009.

Compared to discourse 1, many articles do not provide a definition of HTA, with one article instead referring to 'medical technology assessment' (Radhakrishnan et al., 2014). MedTech is broadly defined, including medical devices, diagnostics, genetic tests, software, healthcare procedures, and health promotion activities. The focus of most articles is on 'high-risk' medical devices. The relation to pharmaceuticals is often explicitly mentioned, often MedTech are even defined as non-pharmaceuticals (Green & Hutton, 2014; Varela-Lema et al., 2012). Commonly, a list of differences is given between MedTech and pharmaceuticals, focusing on differences in evidence and including as reasons less stringent regulatory requirements and an iterative development of MedTech (Campbell et al., 2018; Crispi et al., 2019; Kovács et al., 2022; Tarricone et al., 2020). With regards to evidence, real-world data (RWD) also becomes important, as articles make the point that feasibility issues or problems with patient recruitment limit the availability of RCTs for some MedTech (Leng & Partridge, 2018; Srivastava et al., 2023; Varela-Lema et al., 2012).

In relation to other stakeholders, HTA agencies should influence industry and clinical experts to focus more on evidence generation and usage, respectively. Both stakeholders are sometimes portrayed as reluctant (Campbell, 2011b; Green & Hutton, 2014). Because the HTA agency has limited mandate to impose on either, it should focus on encouragement. Regarding industry, HTA agencies need to encourage industry to conduct better studies (Campbell et al., 2017). It is argued that device manufacturers are not accustomed to producing the type of evidence needed for HTA as they are inexperienced or lack resources (Blankart et al., 2021; Campbell, 2013; Campbell et al., 2017). It is the role of HTA agencies to encourage MedTech industry to generate 'better' or 'more mature' evidence (Alshreef et al., 2016; Campbell, 2013; Campbell et al., 2017; Campbell & Knox, 2016; Green & Hutton, 2014). In addition, HTA agencies need regulators to set better evidence requirements for market entry (Green & Hutton, 2014; Tarricone et al., 2020; Vinck et al., 2007). Regarding clinicians, HTA agencies need to encourage clinicians to update their practice in response to new evidence (Campbell, 2011b).

Discourse 3: The HTA agency as convenor – Sandboxing, living labs, and testbeds

The third discourse gives meaning to the HTA agency as a process manager or convenor. The role of HTA agencies in relation to MedTech is to be a bridge between stakeholders (Andradas et al., 2008) or a 'boundary organization'(Wehrens & de Graaff, 2024). This discourse emerged around the same time as discourse 2 but is less dominant (Figure 2). Articles argue that HTA agencies need to broaden their scope to deal with technological developments. As HTA agencies do not have the resources to govern the vast number of MedTech alone, they increasingly need to collaborate with others. In doing so, they need to be pragmatic and balance different perspectives. In contrast to discourse 1 and 2, where robustness was highlighted, flexibility is emphasized (Dutot et al., 2017; Weh-

rens & de Graaff, 2024). 16% of included articles represent this discourse (Table 1). Most articles were published in HTA and public health journals, such as the IJTAHC (45%), the Journal of comparative effectiveness research (10%), and the International Journal of environment research and public health (10%). Most articles are about Europe in general (78%), often mentioning the recent EU regulations (see Supplementary Materials). This discourse includes no articles about the UK.

MedTech are described either very broadly, e.g., "tests, devices, vaccines, procedures, programs, or systems" (Greenwood Dufour et al., 2022) or more specifically, e.g., digital health (Facey et al., 2020; Oortwijn et al., 2018) or diagnostic technologies (Cacciatore et al., 2020). They are not described as non-pharmaceuticals, as was more common in discourse 2. When HTA is defined, articles often refer to the broader, updated definition of HTA (O'Rourke et al., 2020). Reference to the multidisciplinary nature of HTA is also already made before this updated definition (Dutot et al., 2017). Evidence is understood in a broad sense, including social, ethical, and legal factors next to clinical and economic ones, and warrants interpretation (Bloemen & Oortwijn, 2024; Greenwood Dufour et al., 2022; Oortwijn, Husereau, Abelson, Barasa, Bayani, Canuto Santos, et al., 2022; Oortwijn, Husereau, Abelson, Barasa, Bayani, Santos, et al., 2022). It is frequently referred to as 'best available evidence' (Furman et al., 2022). Whereas in discourse 2, the lack of evidence for MedTech is something HTA agencies must actively improve, in this discourse it seems to be interpreted more as a given. To deal with this lack of evidence, participatory (Oortwijn, Husereau, Abelson, Barasa, Bayani, Canuto Santos, et al., 2022; Oortwijn, Husereau, Abelson, Barasa, Bayani, Santos, et al., 2022), exploratory (Greenwood Dufour et al., 2022; Leckenby et al., 2021; Tummers et al., 2020) and pragmatic (Rochaix & Xerri, 2009) approaches to MedTech governance are preferred, including sandboxes, living labs and testbeds. At the same time, it is questioned whether the historical commitment to neutral evidence may conflict with these new approaches for MedTech (Bloemen & Oortwijn, 2024).

Emphasis is placed on collaborations, including between international HTA agencies (Simpson & Ramagopalan, 2022), between local and national HTA agencies (Dutot et al., 2017), between HTA agencies and industry (Leader, 2008), and between all relevant stakeholders (Facey et al., 2020; Oortwijn et al., 2018). This discourse mentions the widest variety of stakeholders, including clinicians, hospitals, industry, regulators, patients, policy makers, and citizens. The assessment should be developed in consultation with these stakeholders, to increase transparency, deliberate on RWD, and address context dependence and user experience (Bloemen & Oortwijn, 2024; Facey et al., 2020; Rochaix & Xerri, 2009). Similarly to discourse 2, there seems to be a focus on earlier involvement, e.g., early HTA as a joint effort between different stakeholders to inform

investment decisions (Leckenby et al., 2021; Tummers et al., 2020). The epistemological problems that such (early) involvement may introduce are emphasized and reflected on (Bloemen & Oortwijn, 2024; Leckenby et al., 2021; Oortwijn, Husereau, Abelson, Barasa, Bayani, Canuto Santos, et al., 2022; Oortwijn et al., 2018; Tummers et al., 2020; Wehrens & de Graaff, 2024).

Discourse 4: Critical reflection on the level of normative reflection of HTA agencies – the technocratic hope of a value-free arm's length agency

In the fourth discourse, the level of reflection on normative aspects of the role of the HTA agency is critically questioned. For example, it is argued that the language of evidence may obscure underlying political disputes, "*pushing issues of income, policy, and turf below the surface"* (Syrett, 2003). Lack of transparency about such issues may affect the legitimacy of HTA agencies (Syrett, 2003). Articles argue that while some legitimacy issues may be repaired through increased participation from clinicians, patients, or the public, this also introduces new legitimacy problems (Burls et al., 2011). 6% of included articles belonged to this discourse (Table 1). Articles are distributed across journals like Health Policy, Health Economics, and Health Ethics, as well as several clinical journals. About half of articles are about the UK (57%) and half about Europe (43%).

MedTech are defined very broadly, with articles mentioning examples of MedTech, pharmaceuticals, and health care systems. In other towards, this discourse of critical reflection on the role of HTA agencies and their level of normative reflection includes yet extends beyond MedTech. HTA is described as necessarily value laden, with ethical issues arising when deciding on which technologies to prioritize, which methods to use, how issues are framed, and which stakeholders' values are considered (Burls et al., 2011). One article mentions how many factors impact decision making, e.g., "*uncertainty, budget impact, clinical need, innovation, rarity, age, cause of disease, wider societal impacts, stakeholder influence and process factors",* and that the interaction of these factors should be better understood (Charlton, 2022). Other articles explore whether HTA agencies are gender - (Panteli et al., 2011) or age sensitive (Douglas, 2012). Lastly, this discourse reflects on the distinction between a value-free assessment phase and a value-laden appraisal phase, arguing that while this may be helpful for defining roles, it should not exclude explicit value considerations in the assessment phase (Burls et al., 2011).

Discourse 5: Critical reflection on the level of nuanced clinical expertise of HTA agencies – overriding clinical responsibility

The last discourse critically reflects on the role of the HTA agency in terms of their level of nuanced, clinical expertise. The HTA agency is said to not always understand how a

lack of nuance, clinical expertise impacts patients and their families (Gala et al., 2022). Articles argue that HTA agencies can only provide guidance to clinicians regarding MedTech, and their responsibility to be transparent and avoid data redaction in published guidance is emphasized (Osipenko, 2021). 7% of included articles belonged to this discourse (Table 1). Most articles were published in clinical journals, such as BMJ (or BMJ open) (50%) or Heart (20%). All articles in this discourse were about the UK, with criticism often directed at NICE's role in developing guidelines.

A description of HTA is often not given, except in one article where it is explicitly placed in the order of 'hurdles', i.e., after demonstration that a technology is "*pure, efficacious, and safe*" it also needs to be "*better in some way than what is currently available*" (Smith, 1999). This discourse urges the HTA agency to closely collaborate with clinicians (Chisholm, 2014; Leng et al., 2018; Vyawahare et al., 2014). This discourse differentiates explicitly between different technologies and includes the most references to specific MedTech, describing their unique clinical contextual relevance. It argues that HTA would be more fitting if it were either done for all technologies, or for none at all. Because HTA agencies currently often focus on certain types of technologies, it is considered difficult for clinicians to weigh decisions about treatments, beds, nurses, diagnostic equipment, etc. (Smith, 1999) Regarding evidence, it is argued that research literature often does not represent real-life practice, with clinicians sometimes needing to include other factors, including peer support (Chisholm, 2014) and patient needs (Gala et al., 2022)

Discussion

Based on a comprehensive literature review and discourse analysis, we constructed 5 discourses. Each discourse frames HTA, MedTech, and evidence in a different way and presents a different story of the role of HTA agencies in the governance of MedTech. The first discourse describes the HTA agency as an independent evaluator of appropriate evidence for all health technologies. The second discourse explicitly distinguishes MedTech as separate from pharmaceuticals and expands the role to include stimulating evidence generation for MedTech. The third discourse describes the HTA agency as a convener of stakeholder perspectives, emphasizing flexibility and experimental approaches. The fourth discourse critically reflects on the level of normative reflection and how lack of reflection could undermine the legitimacy of HTA agencies. The fifth discourse critically reflects on the level of nuanced, clinical expertise of HTA agencies and urges more collaboration more closely with clinicians.

Most importantly, our study explores how the role of HTA agencies in relation to MedTech is interpreted differently across the academic literature. This is important to keep in mind in light of institutional developments at the EU level. In addition to the procedural and legal discussions surrounding the introduction of regulations such as the HTAR, it is equally important for policymakers to reflect on the broader, more ideological questions of what these developments mean - or should mean - for the role of HTA agencies in MedTech. It appears that, at least in the academic literature, discourses on this role differ in terms of their degree of distance from and dependence on other stakeholders. Further reflection on the position of HTA agencies in relation to other stakeholders in MedTech governance is therefore warranted. To the best of our knowledge such a review has not been done before.

Furthermore, all discourses refer to some extent to how a lack of evidence for innovative MedTech complicates the role of HTA agencies. We particularly wish to underline a normative friction between the scarcity of evidence and the traditionally dominant discourse of the HTA agency as an independent evaluator of appropriate evidence. In the scarcity of evidence surround MedTech, the normative complexity of what HTA agencies should and should not do seems to be increasing (Bloemen et al., 2024). With the JCA of certain high-risk medical devices from 2030 onwards, this normative complexity of the work of HTA agencies regarding MedTech may further amplify, bringing these discussions 'above the surface' (Syrett, 2003). We therefore recommend further reflection on this matter by policy makers and believe the identified discourses can be of use in such discussions. The goal here would not be to categorize HTA agencies into a specific discourse, as the discourses are ideal-typical and multiple discourses can co-exist within an institution. However, reflection on where the HTA agency stands, or wishes to stand, in terms of its role in MedTech governance and what different ways of framing MedTech and evidence do for this role, can be elusive in further developing the MedTech policy framework.

In particular, two opposing framings around this lack of evidence for MedTech appear from our analysis. Discourse 2 focuses on the role of HTA agencies in prompting better evidence generation for MedTech. This discourse has become increasingly dominant over the last 15 years. Discourse 3 has intensified more recently, starting around 2020, and reflects a more facilitative and experimental role to MedTech governance. In addition, both discourses 2 and 3 discuss earlier involvement by HTA agencies. However, in discourse 2, the aim of such early engagement is mainly to "*set the right incentives for manufacturers to initiate change*" (Blankart et al., 2021), and in discourse 3, such early engagement is discussed in terms of the "*the aim of mutual learning and adaptation*" (Leckenby et al., 2021). Whereas in Discourse 2, the lack of evidence for MedTech seems

to be described as something that HTA agencies must actively change, in Discourse 3 it seems to be interpreted as more of a given for MedTech, and HTA agencies must work around this lack of evidence by engaging in flexible, experimental approaches.

Building on the findings of this study, we recommend several directions for future research. In general, we recommend research on how the role of HTA agencies in MedTech governance plays out in practice, to understand what the identified conflicting discourses mean for the day-to-day level of MedTech policymaking. It would be interesting to see whether, in practice, HTA agencies do indeed take the more dominant, independent approach to MedTech governance, or whether they adopt more instigative or more participatory approaches, and what this means for the other stakeholders involved. It is likely that strategies for MedTech governance will require different approaches for different circumstances, but as our review and in particular Discourse 4 highlights, a lack of reflection on the normative aspects of different roles can undermine the legitimacy of HTA agencies (Burls et al., 2011; Syrett, 2003). In particular, in light of the opposing framings of the role of HTA agencies in relation to a lack of evidence for MedTech, we believe it would be interesting to follow how this discrepancy plays out in practice, as it would be interesting to see how HTA agencies navigate more acute issues of scarcity of MedTech evidence. In general, we note that the more critical Discourses 4 and 5 were relatively underrepresented in the literature. This suggests a need for more explicit and sustained reflection in future research on the normative foundations of HTA's role in MedTech governance.

Finally, we would like to reflect on the strengths and limitations of our study. By combining a systematic search with a discourse-analytic approach, we provided a comprehensive overview of how the role of HTA agencies in relation to MedTech is interpreted across the academic literature. To the best of our knowledge, this is the first review specifically addressing how this role is framed differently across scholarly discourse. Such a review is a critical step towards enhancing our understanding of the governance of MedTech. However, our reliance on academic literature introduces certain limitations. For instance, our review may reflect a skewed perspective, as scholars from some countries, such as the UK, publish more extensively on this topic than others. This is evident in the overrepresentation of NICE in our analysis, which can be attributed to their frequent publication of processes in the academic domain and their explicit MedTech Evaluation Programme (MTEP). Nonetheless, given NICE's prominent international profile (Sculpher & Palmer, 2020), their significant representation in our review is both expected and reflective of their leadership in the field. Additionally, because specific language is an integral part of discourse analysis, we restricted our review to English-language publications to avoid having to translate texts and potentially miss

metaphors or nuances. This decision, while pragmatic, further limits the scope of our analysis, potentially excluding discourses from non-English-speaking countries. These limitations should be considered when interpreting our findings.

Conclusion

Overall, our results provide an interpretive framework on how the role of HTA agencies in relation to MedTech is interpreted differently across the academic literature and over time. Although the newly updated definition of HTA foregrounds its multidisciplinary nature, and new European regulations increase the role of HTA agencies in relation to the governance of MedTech, our study signifies that there are discrepancies in the interpretation of this role in the academic literature. Some of the constructed discourses are more dominant in earlier years, while others appear to be emerging or gaining prominence more recently. Importantly, our study does not make claims about the current prevalence of each discourse at a specific time point. To evaluate that, additional empirical work (e.g., using grey literature, policy documents, or interviews) would be needed. We do highlight in particular how all discourses seem to refer to some extent to how a lack of evidence for innovative MedTech complicates the role of HTA agencies, and two opposing framings around this lack of evidence for MedTech appear from our analysis. Based on our more explorative findings, we recommend that more empirical research be conducted on how different framings of the role play out in practice, and what this means for the governance of MedTech by HTA agencies. The way in which the role of HTA agencies in relation to MedTech is framed in the academic literature can influence governance by shaping perceptions, legitimizing decisions, and guiding action (Blume, 2009; Burau et al., 2021; Ciani et al., 2016; Nelson et al., 2021). Understanding and reflecting on the different academic discourses is therefore crucial, for furthering the academic debate, increasing our understanding and advancing MedTech governance.

CHAPTER 3

Micro-Regimes Of Anticipation In Public MedTech Governance

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Anticipating emerging medical technologies: The start of an international horizon scanning tool for medical devices

Abstract

The governance of innovative medical technologies is fraught with uncertainties. Responsible governing bodies prepare for future advances by engaging in anticipatory practices aimed at knowing and acting earlier-on, but little is known about such work. We examine an anticipatory practice of a multinational, mostly European horizon scanning collaboration, drawing on the analytical framework of anticipatory governance and micro-regimes of anticipation. We distinguish four inter-related micro-regimes that emerge from participants' expectations of a horizon scanning tool. We show how all micro-regimes relate to ideas about anticipatory governance that focus on prediction and reducing uncertainties. Moreover, participants' expectations about the tool are vested on prior experiences with horizon scanning for pharmaceuticals. We argue that this may affect the governance of medical technologies that do not fit a linear approach, conventional for pharmaceuticals, but develop more iteratively. Finally, we highlight the importance as well as the complexity of engagement between different stakeholder groups. Overall, we conclude a need for anticipatory practices to become more reflexive about the consequences of future visions, the assumptions behind them, and the implications for the actions needed in the present. This would increase the relevance and value of policy tools developed for the governance of emerging medical technologies.

1. Introduction

> *"If we could say, right, in two years' time, there will be this possibly disruptive technology coming in…. If we could capture that in a horizon scanning report, it could inform decision-makers, give us time to establish an assessment and funding plan, and enable the healthcare system to adopt a more strategic introduction of said technology. This would reduce the risk of a broad and costly introduction without sufficiently robust evidence of its benefit." (Participant 4, International Horizon Scanning Initiative Medical Devices Working Group, 'IHSI MDWG', 20-01-2022)*

Medical technologies are constantly being developed and introduced into healthcare systems. Because of medical technologies' (potential) impact on the financial sustainability of healthcare systems, they are often subjected to some form of governance. Governance of medical technologies is complex, however. For one, there is tension between governing ('knowing before you continue') and innovating ('continuing before you know'); the quote above highlights this tension in terms of a desire for more time to prepare for "*more strategic introduction*" of technologies. This tension has resulted in the pacing problem—i.e., the growing gap between the development of innovative technologies and their governance, specifically in terms of their legal and ethical control (Marchant et al., 2011; Wallach et al., 2018)—leading to the belief that the current governance approach is no longer "fit for purpose" (Mathews et al., 2022, p. 2239).

One complicating factor is the tension between prospective claims and empirical information already available about emerging medical technologies (Mittelstadt et al., 2015). Uncertainties about present and future benefits, risks, and applications are manifold (Mathews et al., 2022; Wallach et al., 2018). This lack of initial certainty about the added value of a technology creates room for certain ideologies to be expressed in the initial stages of development (Wallach et al., 2018). This could, in theory, encourage caution, but in practice often begets overpromising (Stevens, 2018, 2022). Beyond these initial stages of development, Abrishami et al. (2020) show that the evidence base often contains conflicting, sometimes polarized arguments on the (added) value of emerging medical technologies. This means that awaiting further studies with *"sufficiently robust evidence"* might not always be the answer.

A second complicating factor is the difficulty of identifying at which point 'knowing' can occur. Specific ideas about what constitutes *"sufficiently robust evidence"* define 'knowing' in the medical field (Wilkinson & van Boxtel, 2019). However, the development of medical technologies typically takes an iterative approach and often involves

a learning curve for the user (Bluher et al., 2019; Enzing et al., 2021; Rothery et al., 2017; Tummers et al., 2020). This is conceptually captured in the Collingridge dilemma (Collingridge, 1980). In the beginning of an emerging technology's development, it is relatively easy to control or influence it, but uncertainty and scarce evidence make it difficult to decide how to influence it. Once a technology has been developed and is more widely used, its societal impact is more concrete, but it becomes more expensive and time-consuming to influence it.

A third complicating factor is a 'diffusion across boundaries', as governance is dispersed across jurisdictions (Mathews et al., 2022). No single agency bears full responsibility or has all relevant information pertaining to emerging medical technologies. Stakeholders need to cooperate to anticipate and prepare (Mathews et al., 2022; Wallach et al., 2018). Such dynamic collaboration may be difficult because stakeholders' values may conflict. For example, conventional governance mechanisms for emerging medical technologies focus primarily on individual safety (Mathews et al., 2022). These existing mechanisms are not always equipped to take broader value issues into account, such as public safety, equity, affordability, accessibility, or efficiency.

In light of these complicating factors, healthcare regulators have recently started experimenting with prospective approaches. Governing bodies aim to know and act on information earlier, attempting to prepare for the future (Kickbusch, 2014). Notions of 'early warning and alert systems', 'early dialogues with industry', and 'early Health Technology Assessment' are increasingly popular in the governance sphere of emerging medical technologies (Fuchs et al., 2017; IJzerman et al., 2017; Ijzerman, 2011; Kickbusch, 2014). A prospective approach to the governance of emerging medical and other technologies is described in the literature as 'anticipatory governance'. Anticipatory governance refers to governance processes that use anticipation to engage with uncertain futures and guide action in the present (Muiderman et al., 2022). Activities of anticipatory governance are termed anticipatory practices or processes. These practices often involve tools that help engage with the future, analyze and deliberate on uncertainties, and determine actions in the present. Examples are horizon scanning (HS), trend watching, scenario workshops, focus groups, econometric modelling, and simulation gaming (Barben, 2008; Muiderman et al., 2020). In this paper, we focus on HS in the context of healthcare policymaking for medical technologies. HS can be understood as a policy tool that systematically examines developments to identify gaps in knowledge and prepare for these gaps (van Rij, 2010). HS is not only technically complex but also value laden. Aykut et al. (2019) argue that decisions based on anticipatory practices (like HS) tend to mimic the politics of the actors and systems engaged in these practices. It is therefore important to assess how actors conceptualize the

future in anticipatory practices, and the implicit and explicit assumptions underlying such conceptualizations (Muiderman et al., 2020).

There are, however, few studies on how governing bodies engage in anticipatory practices, especially around governance of medical technologies (Heo, 2021). Most focus on anticipatory practices in climate governance (e.g., Dolez et al., 2019; Levidow & Raman, 2020; Muiderman, 2022; Neale & May, 2020). Few studies analyze anticipatory practices in the context of healthcare governance (e.g., Rychnovska, 2021; Viseu, 2015), even though such practices are gaining importance for healthcare decision-making. No other case study has, to the best of our understanding, specifically examined how agencies across different countries engage in HS in the context of healthcare governance. In this article, we follow the early stages of an international HS tool for medical devices,[3] developed by the International Horizon Scanning Initiative Medical Devices Working group, whose membership is drawn from several countries in Europe and one in North America (Canada). In doing so, we investigate the governance of medical technologies in the earlier stages of the medical devices' lifecycle, i.e., from innovation up to early adoption (including pre-regulatory phases and approval) but before large-scale use (see Figure 1). We draw on the anticipatory governance literature and the notion of "micro-regimes of anticipation" (Dolez et al., 2019) to examine how specific ideologies, i.e., ideas about the 'good future', emerge and how they point towards tensions between the different micro-regimes shaping the tool in the making. In light of the complicating factors described above, we ask: What micro-regimes of anticipation exist in the expectations of those collaborating on the international HS tool for medical devices? What tensions emerge between these micro-regimes of anticipation? How are expectations shaped and how do they shape the governance of emerging medical technologies? Below, we first elaborate on the theoretical framework and our case study. We then explain how we collected and analyzed our data. We subsequently discuss our empirical findings and analysis regarding the international collaboration on HS for medical devices and discuss the theoretical and practical implications of our findings as well as any limitations .

3 There is some discussion concerning the difference between medical *technologies* and medical *devices*. Initial discussions suggested that the term medical *technologies* is used more often in industry settings and medical *devices* in regulatory settings. Because this discussion was ongoing at the time of writing, both in the working group and in the literature, we use these terms interchangeably in this article.

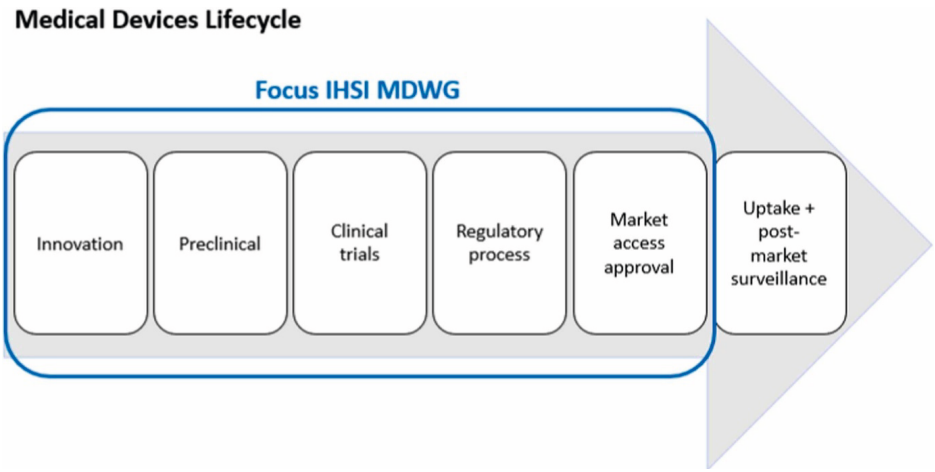

Figure 1. Medical Devices Lifecycle and focus of the International horizon Scanning Initiative Medical Devices Working Group

2. Conceptual approach: Anticipatory governance and micro-regimes of anticipation

The term *anticipatory governance* originates in diverse literatures, including future studies (e.g., Fuerth & Bezold, 2009), science and technology studies (e.g., Guston, 2014), sustainability science (e.g., Boyd et al., 2015), and public administration (e.g., Chi, 2008). As a theoretical framework, anticipatory governance has been applied to the governance of a wide range of emerging technologies (Fisher et al., 2012; Nelson et al., 2021; Ozdemir et al., 2011), and environmental sustainability (Dolez et al., 2019; Muiderman, 2022; Neale & May, 2020). The concept of anticipatory governance is useful in fields characterized by uncertain futures, multiple actors involved in the governance of those futures, and potentially high risks associated with a failure to act in the present. Both Muiderman et al. (2020) and Uruena (2022) identify four, broadly overlapping approaches to anticipatory governance. Below we summarize the key features of these different approaches.

2.1: Anticipatory governance to predict the future

One way to engage with the future through anticipatory governance is to try to predict and prevent future risks and shape future opportunities. This deterministic approach is prominent in public policy and planning literature (Börjeson et al., 2006; Fuerth & Bezold, 2009) and health technology assessment (Ozdemir et al., 2011), in which anticipatory practices (e.g., econometric model calculations, technological forecasting,

budget analyses) are used to assess the probability of futures, with risk reduction as the ultimate aim (Muiderman et al., 2020). A key characteristic is the belief that although the future is complex, it can be (closely) predicted, and future risks can be managed, minimized, or even prevented.

2.2: Anticipatory governance to strategically build capacity for the future

The second approach to anticipatory governance appears to contest the ability to predict a single deterministic future (Muiderman et al., 2020). This approach sees more fundamental uncertainties or issues ahead, which makes different futures plausible that cannot be reduced to a single, most-likely future (Guston, 2014; Selin, 2011). The focus is on envisioning plausible futures by engaging a variety of stakeholders and integrating their different viewpoints. This is considered vital for building capacity to address these diverse futures (Barben, 2008; Guston, 2014). Although the futures envisioned are less deterministic than in the first approach, the anticipatory practices (e.g., visioning exercises, focus groups, scenario development workshops) still have clear strategic and normative force regarding which futures *should* be envisioned and engaged with, and similarly assume that uncertainties can be minimized (Urueña, 2022).

2.3: Anticipatory governance to collectively imagine futures

The third approach contests the idea of plausibility altogether (Muiderman et al., 2020). In this approach, "plausibility" is seen as subjective and depending on interactions between actors and ways of interpreting the world. This means different futures can be conceivable for different stakeholders and audiences. The aim of anticipatory governance, then, should be to imagine pluralistic futures. Rather than attempting to know *the* future, this approach enriches the possibilities that are considered in the present (Urueña, 2022). The anticipatory practices are typically more experiential in nature (e.g., simulation gaming, scenario workshops), and they embrace uncertainty and enrich decision-making processes by enhancing the technical, moral, and political imagination of the actors involved.

2.4: Anticipatory governance to critically analyze anticipatory practices

The fourth approach critically reflects on all anticipatory practices' engagement with the future. The argument is that while such imaginaries of the future may (still) be speculative, they can performatively privilege certain visions (Jasanoff & Kim, 2009; Muiderman et al., 2020). Performativity means that practices proactively frame problems, shape perceptions, legitimize decisions, and guide actions (Gond et al., 2015; Hutchby, 2001). The aim is to show the political implications and consequences of anticipatory practices by critically reflecting on their performative power (Muiderman et al., 2020). As in approaches 2 and 3, futures are (somewhat) unknowable, but this

approach emphasizes that any attempt to make futures knowable inevitably privileges ways of envisioning the future and dealing with uncertainty. For instance, framing of the future by anticipating "climate emergencies" could legitimize the development of certain solutions in the present.

2.5 Micro-regimes of anticipation

These four approaches to anticipatory governance point to how different expectations of the future may coexist both in and between different stakeholders. As some expectations of the future may be more prominent than others, notions of politics, power, and inequality become important in anticipatory practices (Brown, 2014). This political aspect of anticipatory practices is grasped through what Dolez et al. (2019) have termed 'micro-regimes of anticipation' in their study of forest scientists. A regime of anticipation accounts for how decision-makers employ *"practices, infrastructures, and imaginaries to anticipate the not yet"* (p. 81). The notion of a 'micro' regime, Dolez et al. (2019) argue, is located at the smaller level of day-to-day agendas and practices. In anticipatory practices that involve multiple actors, views, and values, various micro-regimes of anticipation co-exist and may conflict. In their view, a micro-regime of anticipation contains an anticipatory objective, a framing of the issue at hand, a vision of the future, a 'modelling practice', and a preferred interaction with other stakeholders. This adds several layers to the study of anticipatory practices by Muiderman et al. (2020) and Uruena (2021). One of these is the framing of the issue. Dolez et al. (2019) show how the different 'types' of scientists they interviewed had different visions of the issues at stake. Additionally, they show how in each micro-regime, a different approach is chosen towards modelling the future, and how each micro-regime prescribes a particular way of interacting with other stakeholders involved. Finally, in each micro-regime, 'Big Futures' and 'Little Futures' are at play (Michael, 2017). Big Futures are visions that entail substantial changes over a longer time horizon with far-reaching implications. Little Futures entail smaller changes with a shorter time horizon, enacted through today's local practices and processes.

In our analysis, we use the four approaches to anticipatory governance to ask the following questions of the micro-regimes of anticipation we identify: How is the future conceived in the expectations of the participants? How are uncertainties framed, and which types of actions are preferred? Who is invited to join (engagement and integration) and who is not? What are the political and performative aspects of the anticipatory practice? These questions allow us to analyze how the future is shaped and framed in our case study, which is described in more detail below.

3. Case description: The International Horizon Scanning Initiative Medical Devices Working Group

Our case is a collaboration initiated by the International Horizon Scanning Initiative (IHSI). IHSI was established in 2019 (https://ihsi-health.org/). It originated from the "BeNeLuxA Initiative," which was established by national organizations in Belgium, the Netherlands, Luxembourg, Austria, and Ireland (https://beneluxa.org/). IHSI goes beyond the coalition of countries that started the BeNeLuxA Initiative. Its aim is to provide "*a permanent horizon scanning system that can support countries and institutions in policy planning and their decision-making regarding the reimbursement of new pharmaceuticals*" (http://www.beneluxa.org/), reimbursement here referring to compensation through national health insurance systems. IHSI initially focused its collaborative HS efforts on pharmaceuticals. It scans open sources (such as clinical trial registers) for information pertaining to emerging pharmaceuticals. Innovation in the pharmaceutical industry has traditionally been organized largely according to a linear model of drug discovery, preclinical tests, safety, and efficacy trials, followed by market access. Although this linear model has been questioned recently (e.g., Smits & Boon, 2008; Ginsburg & McCarthy, 2001), still, clinical trial information is frequently gathered in centralized locations in a stepwise manner. The IHSI pharmaceuticals HS database thus follows a similarly stepwise approach: ingest, preprocess, evaluate, compute, and distribute (https://ihsi-health.org). In 2021, IHSI established a working group to develop a workplan for a joint HS tool for medical devices, the IHSI Medical Devices Working Group (IHSI MDWG). Table 1 describes IHSI MDWG in May 2022, representing nine European countries and Canada.

Table 1: International Horizon Scanning Initiative Medical Devices Working Group, participating organizations (in May 2022)

Country	Organization	Main line of activity
Austria	Austrian Institute of Health Technology Assessment	Health Technology Assessment (HTA), reimbursement, and quality assessment
Belgium	Belgian Health Care Knowledge Center + National Institute for Health and Disability Insurance	Health Technology Assessment (HTA), reimbursement, and quality assessment
Canada	Canadian Agency for Drugs and Technologies in Health	Health Technology Assessment (HTA), reimbursement, and quality assessment
Denmark	Danish Medicines Agency	Regulatory affairs and market surveillance
Italy	Bocconi University	Academic research
Luxembourg	Luxembourg Health Directorate	Regulatory affairs and market surveillance
Netherlands	National Health Care Institute	Health Technology Assessment (HTA), reimbursement, and quality assessment
Norway	Norwegian Institute of Public Health	Health Technology Assessment (HTA), reimbursement, and quality assessment
Portugal	National Authority for Medicines and Health Products	Health Technology Assessment (HTA), reimbursement, and quality assessment + Regulatory affairs and market surveillance
Sweden	Dental and Pharmaceutical Benefits Agency + Swedish Association of Local Authorities and Regions	Health Technology Assessment (HTA), reimbursement, and quality assessment

Despite differing national systems, international collaborations like IHSI MDWG are deemed desirable because development of medical devices is usually not limited to the national level (Oortwijn et al., 2018). HS has proven challenging at the national level because of the vast number of medical devices under development and the wide variety of information pertaining to these devices. International collaboration is therefore seen as a way to share skills and experience, co-develop methodological approaches, and exchange information about emerging healthcare technologies (Packer et al., 2015). In addition, new and existing EU regulations appear to make collaboration on HS more desirable, including the Medical Device Regulation (MDR) and the Health Technology Assessment Regulation (HTAR). The MDR stipulates the regulatory requirements that medical devices must meet to be considered CE-certified and gain market access in the European Union (EU, 2017a, 2021b). There is debate as to whether the MDR intensifies the focus on clinical evidence in market access decision-making for medical devices (Shatrov & Blankart, 2022; Wilkinson & van Boxtel, 2019). This could affect timelines and the amount of evidence available for HS of medical devices. The HTAR offers guidance for joint efforts between EU Member States on Health Technology Assessment (HTA)-related activities, including joint HTA of medical devices (EU, 2021b). HTA is a

standardized, evidence-based approach to assessing the medical, economic, ethical, and social aspects of health technologies. It is often used in reimbursement decisions at various levels, including the national, regional, or facility level (Drummond et al., 2009). A rise in the number of joint HTAs might make it more desirable to collaborate internationally on HS as well.

4. Data collection and analysis

Our study used an exploratory, multi-method study design based on semi-structured interviews supplemented by ethnographic participant observations and a descriptive survey. We followed the participants of the IHSI MDWG just after the group was formed. We observed the IHSI MDWG closely as members discussed and conducted the necessary research for the first phase of their work plan. We formulated a descriptive survey that served as a starting point for data collection. The survey questions were co-designed with the IHSI MDWG so that the survey would contribute to its work plan and serve as a starting point for our research. The survey addressed member organizations' ideas about the purpose of an international HS system. Nine different purposes were predefined by the IHSI MDWG, and participants were asked to rank these purposes in order of perceived importance and add other purposes if necessary. The survey also included questions related to the desired scope and time horizon of an international HS tool. The survey was drafted using the Qualtrics software package and was sent to representatives of the IHSI MDWG participating organizations (n=10) in December 2021 (see Supplementary Appendix A).

The questionnaire was used as input for online, semi-structured, in-depth interviews with the same representatives of participating organizations. The interviews allowed us to spark a broader discussion of participants' expectations of HS for medical devices and the purposes served. A topic list guided the interviewer (see Supplementary Appendix B). All participants were asked to reflect on the expected objectives, benefits, and challenges of an international HS tool for medical devices. In addition, we discussed expectations concerning relevant regulations such as the MDR and the HTAR, and how these impacted the participants' expectations. The interviews involved a single interviewer and one or two interviewees, except for the interview with the Belgian representatives, which had two interviewers and four interviewees (two from each of the two participating Belgian organizations). In total, ten interviews were conducted between January and March 2022, all lasting 60 minutes. Two interviews were held in Dutch and the rest in English.

In addition to the interviews, we observed participants in the IHSI MDWG between October 2021 and October 2022 both at the Dutch National Health Care Institute (hereafter: the Institute) and during the IHSI MDWG working group meetings. We focused on expectations regarding the international HS collaboration, interactions among the participants, and anticipated issues voiced by the participants about the international HS tool. During those meetings, the first author also supported the IHSI MDWG participants in conducting the work necessary for the second objective of their work plan, i.e., "to map the national needs of the IHSI MDWG participating countries."

We analyzed the survey questions in Qualtrics using descriptive statistics, recorded the interviews using Microsoft Teams, and transcribed them verbatim. The transcripts and field notes from the observations were analyzed thematically and coded both inductively and deductively by the first author, then reviewed independently by BG and PA. DD was primarily involved in further enriching and positioning the analysis. The analysis was performed in Microsoft Word and Atlas.Ti. We followed an abductive theory approach to iteratively build on existing theories of anticipatory governance, micro-regimes of anticipation, and our emerging data. We began by developing the codes inductively, identifying the themes in our discussions, and reflecting on the literature described in the theoretical framework (see Supplementary Appendix C). The analysis was further refined in repeated discussions between the authors, and preliminary results of the analysis were presented as a member check to the participants at a meeting on May 24, 2022. The participants recognized the results and in particular further reflected on the dominance of the HTA micro-regime, which provided further information for our discussion. The final results were also presented to all participants.

Our study took place in the context of our longstanding academic collaboration with the Institute and was therefore partly funded by the Institute. Such an in-depth, ethnographic analysis of Western governing practices in medical technology governance is rather unique in relevant literature. However, being partly supported by one of the participating institutions of the IHSI MDWG meant we took further steps to safeguard our distance, scientific integrity, and independence. To avoid 'going native', we relied on both the methodological steps detailed above as well as on built-in legal boundaries: Researcher independence is guaranteed in the written partnership agreement between the Institute and our research faculty. Further distance was created through the use of a theoretical framework based on the anticipatory governance literature, enabling us to analyze structures and patterns beyond our situated data, as well as through discussions with researchers within our research network at the Erasmus University of Rotterdam and outside of our network during conferences. In addition, as DD served as a lead member of IHSI, she was involved in arranging access to the field but was not

involved in gathering and analyzing raw empirical data. This was deliberately decided by all authors, prior to the data collection phase. The other authors are not affiliated with IHSI. Moreover, our role was solely to conduct this research and it was not the agreement nor the intention that the authors provide ISHI MDWG with advice on its current or future (strategic) direction. Our study has received ethical approval of the Erasmus School of Health Policy and Management (ETH202122-0240). All participants gave their written informed consent before taking part in the study.

5. Results

In this section we describe four micro-regimes of anticipation we identified while studying participants' expectations in the early setup of the IHSI MDWG, portrayed in Table 2. Because our case study focuses on building an international HS tool, we interpreted 'modelling practice' (Dolez et al., 2019) as the way in which the operational aspects of the international HS tool are envisioned. We describe this visualization of the international HS tool and the everyday practices associated with that visualization as the Little Future. The Big Future we describe concerns long-term ideas about the governance of medical technology, i.e., more widespread ideas about its future governance. The four micro-regimes are not mutually exclusive and partly overlap. We have, however, observed tensions between the visions and practicalities of the four micro-regimes, which we reflect on after their description.

Table 2: Characteristics of four interrelated micro-regimes of anticipation in the International Horizon Scanning Initiative Medical Devices Working Group (IHSI MDWG)

Micro-regime	1. HTA	2. Facilitation	3. Regulation	4. Collaboration
Anticipatory objective	To identify early evidence in order to prioritize topics for HTA	To inform decentral or regional actors, to help with procurement	To find disruptive technologies in order to prepare the regulatory framework	To share skills, experiences, and methodologies between countries
Framing of medical devices	Compared to pharmaceuticals, assessed in terms of expected impact, following a linear mode of development	Difficult to control at regional and facilitation level, subject to change due to unforeseen circumstances	Either disruptive or non-disruptive to the regulatory framework, fits or does not fit into the regulatory system	Too many to handle at national level, developed at international level, governable when working together
Vision of the future	Future can be (partly) predicted, and uncertainties can be reduced	Future has some uncertainties, can be managed when working together	Future has some risks, can be managed when working together	Future has some uncertainties, can be managed when working together
Big Future	MD market will resemble market for pharmaceuticals, stricter evidence requirements	Stakeholders have all information, navigate shifting stakeholder priorities	All MD fall within existing regulatory pathway, smooth transition for industry	Reduced workload, more international collaboration, influencing whole trajectory
Little Future	Process of identification, classification, and prioritization, time horizon close to reimbursement	Information gathered by theme, shared with relevant stakeholders, time horizon close to procurement	Producing reports of trends and most disruptive technologies, time horizon early in development	Automated database; flexible tool; translation to national context; negotiating needs and wishes
Approach to uncertainty	Evidence-based	Information-sharing	Risk-based	Collaboration
Relationship to other stakeholders	Battle distrust from industry	Facilitate decision-making	Ensure smooth transition for industry	Stand stronger together

HTA: Health Technology Assessment, AG: Anticipatory Governance, HS: Horizon Scanning, MD: Medical Devices

5.1 Horizon scanning to identify and filter topics for HTA ('HTA')

> *"I would say that the first goal of horizon scanning would be to help prioritize the medical devices to undergo HTA assessment. Because we could collect information on a medical device that we believe could be innovative or really is emerging, and we then need to decide whether we should develop HTA. So, at the moment, horizon scanning could be powerful, useful, important in helping to develop this task." (Participant 12, IHSI MDWG, 01-02-2022)*

The first micro-regime of anticipation was the most prominent one in the working group. In this micro-regime, the participants expect to use HS as a tool to predict which medical devices should be prioritized to undergo HTA, as HTA agencies have limited capacity and cannot assess every device. HS should gather (early) information on medical devices, to determine medical devices' expected impact. Impact is defined by a variety of parameters, such as impact on society in terms of the health care system budget and/or in terms of (dis)similarity to previous technologies for the same medical indication.

The future in this micro-regime is considered complex but manageable. HS is used to deal with uncertainty by determining which medical devices will need assessment. HTA methods should then decrease uncertainties around the effectiveness and cost-effectiveness of medical devices in the future. Uncertainties are thus considered to be manageable, provided that the right process is implemented to collect the available evidence. As participants explain, if robust evidence is lacking, HTA is not possible. Robust evidence is defined as the scientific evidence gathered in clinical trials (like Randomized Clinical Trials [RCTs] or register-based studies), for a specific indication, preferably from large clinical studies involving enough patients. The main uncertainty that participants foresee pertains to the quality of evidence available for emerging medical devices:

> *"Yes, the challenge will be to find good evidence that these devices work and that they are better than what is already there. The instructions or the requirements for scientific evidence before anything goes on the market are much stricter and better regulated for drugs than for medical devices. So, I think you could even say that that may be one of the first conclusions of this working group, that it must be stricter, that it must be better." (Participant 5, IHSI MDWG, 25-01-2022)*

Ideas about robust evidence were derived largely from existing experiences with assessing pharmaceuticals, as many of the working group's participants predominantly have experience with horizon scanning for pharmaceuticals. The quote shows that par-

ticipants expect the working group to conclude that evidence requirements for medical devices must be stricter and should resemble the requirements for drugs. Participants also expect that implementation of the MDR will help reduce the uncertainty around robust evidence; they hope it will require more clinical evidence to be produced before medical devices are allowed to enter the market:

> *"None of us know exactly what the new medical device regulation will change. What HTA expects, or hopes, is that CE marking will be based on far better studies, meaning not only feasibility studies or retrospective case series, but at least on RCTs or register-based RCTs. That would take more time, and so things will take longer, and the time horizon between good evidence, CE marking, and HTA will be shorter. We expect that the large gap between the evidence requirements for CE marking on the one hand and HTA on the other will close with the new medical device regulation. But we don't know for sure." (Participant 3, IHSI MDWG, 19-01-2022)*

HTA organizations thus expect that market approval of medical devices will be based on evidence from *"far better studies."* Currently, HTA organizations typically request additional clinical studies after CE approval has been granted. This, participants state, lengthens the time between European market approval (based on CE approval) and national reimbursement (based on HTA). Participants expect that MDR-related changes will mean that the rules for medical devices entering the market will more closely resemble those for pharmaceuticals in terms of evidence requirements and assessment. The Big Future envisioned could thus be described as one in which the relevant medical devices are properly assessed using HTA methods, ensuring the affordability and sustainability of healthcare systems, by having stricter clinical evidence requirements that resemble those for the pharmaceutical market.

The international HS tool is envisioned as a database with a step-by-step approach, much like the existing IHSI tool for pharmaceuticals. It consists of the following steps: identification (of emerging medical technologies), selection and prioritization (based on predetermined criteria), potential HTA assessment, and presentation of findings. The HS tool should ideally have a relatively short time horizon, as close as possible to reimbursement decisions, because participants hope that there will be more evidence to conduct HTA at that point. The Little Future could thus be described in terms of discussing what constitutes sufficiently robust evidence for medical devices, designing the process of identification, classification, and prioritization, and determining the time horizon (close to reimbursement).

Concerning the interaction with other stakeholders, participants mention some tensions. This micro-regime relies on information that is provided by stakeholders who are not (currently) involved in the IHSI MDWG. Early evidence on medical devices is gathered from experts like clinicians, medical device companies, or patient forums. As participants explain, stakeholders' willingness to share such information early-on is not warranted. As this micro-regime is mostly guided by the desire to collect sufficiently robust evidence, not gathering this information from other stakeholders would be problematic.

5.2 Horizon scanning to facilitate procurement ("facilitation")

> *"That's one goal for the work [around HS], we want to support the regions in their procurement process. Will each region undertake procurement on its own or could there be collaboration? Another question is how we can follow up our recommendation and check whether the regional decision-makers are following it?" (Participant 1, IHSI MDWG, 13-01-2022)*

In the second micro-regime of anticipation that we identified, the anticipatory objective is to inform decentral or regional actors about medical devices coming to market, to aid procurement. Decentral or regional actors may include hospitals, regional governmental bodies, or health insurers. This micro-regime is especially prominent with respondents from participating countries that have a more decentralized system for medical devices, meaning that actors at regional or facility level are (at least in part) in charge of procurement. Medical devices are framed as sites of limited control for national governing organizations. They are worried that some medical devices may be adopted by regional or decentral actors without consideration of all relevant information. Although the participants feel they cannot control these decisions, they expect to be able to ensure that all local actors are properly informed.

The vision of the future is that risks along the medical device trajectory can be somewhat reduced, by sharing information, but participants also acknowledge unforeseeable changes and uncertainties. Several participants mentioned the COVID-19 pandemic as an example:

> *"It is also difficult to anticipate what jurisdictional decision-making priorities might be, two to three years in advance. We might be able to prepare the system, but the priorities might have shifted. Is any of the horizon scanning we did pre-COVID impacting right now? And nobody is obligated to do anything with the*

horizon scanning that we do. We are a non-binding organization." (Participant 9, IHSI MDWG, 25-1-2022)

The main uncertainty in this micro-regime is a potential lack of control due to the shifting priorities of regional or decentral actors. The expectation of a lack of control manifests itself in two ways. First in the non-binding nature of the information shared (see quote above) and second in the framing of medical device governance as an issue of large numbers of stakeholders and devices. These two factors lead participants to expect that the international HS tool can only go so far in handling uncertainties associated with the governance of emerging medical devices. This is managed by envisioning a process in which all relevant information is gathered, to be shared with all relevant stakeholders. Participants further expect the regional or decentral decision-makers served by the HS tool to identify focal themes (e.g., 'diabetes'). Participants also expect that the process will be iterative, in that constant re-identification and reflection will be necessary depending on how the future unfolds. The Big Future envisioned by participants in this micro-regime of anticipation is thus about informing all relevant regional or decentral actors of emerging medical technologies, and that those actors will respond accordingly to the thematic information shared.

The HS tool in this micro-regime is envisioned as an information repository for medical devices based on predetermined themes. Because the anticipatory objective is to inform other stakeholders, a wider range of stakeholders is expected to be involved in choosing thematic foci. These stakeholders, however, do not actively gather data but are considered receivers of information. In the Little Future, participants expect to gather all relevant information for a specific theme (e.g., all emerging medical technologies for diabetes) and share this information with all relevant stakeholders. The time horizon envisioned is close to procurement by regional actors.

5.3 Horizon scanning to inform decisions related to regulation ("regulation")

"[The goal is to be] able to look far ahead so that you can adjust your regulations accordingly. That can take several years, so yes, the sooner you know what is coming on the market, the better. Especially if there are new technologies that are highly disruptive." (Participant 8, IHSI MDWG, 25-1-2022)

In the third micro-regime of anticipation, the objective is scanning for emerging trends and disruptive technologies to prepare the international and national regulatory framework. Medical devices are framed as being either disruptive or non-disruptive, based on whether or not they fit into the existing regulatory system. Attention is thus focused on

disruptive innovations, including both early-stage, broad technological developments and specific devices. Participants mention examples like advances in nanotechnology, artificial intelligence, and digital or mobile health apps. Because these are (relatively) new, their regulatory framework may need to be amended or created from scratch. In this micro-regime, the sooner one is aware of these developments and devices, the earlier one can start those processes:

> *"We asked [our national HTA agency] to develop a new regulatory framework for digital health technologies… We are working on that now, but it takes time, and, in the meantime, we need to make do with what is available. And if there had been a horizon scanning initiative, we could have already started working on it earlier and accelerated the response from the [national HTA agency]." (Participant 5, IHSI MDWG, 25-01-2022)*

The way uncertainties are framed in this particular micro-regime is through a risk-based approach. According to the participants, deciding on the risk level of an emerging medical technology helps determine the necessary level of attention. The risk level of medical devices that are already more developed is defined in (inter)national regulations (such as the MDR) as the potential for occurrence of harm and the severity of such harm, and determined during the CE-certification process. Broader technological developments were also coded as potentially high risk by the participants, here because of their uncertainty in terms of limited information available. The uncertainties in this micro-regime, which are framed as risks, are then managed by considering a longer time horizon which gives regulatory decision-makers time to prepare for the disruptive technologies identified, and to gather more information on their level of risk. Finally, maintaining closer links to industry helps manage the uncertainties framed as risks. The hope is that an "open dialogue" with industry from the earliest stages of development will help to spot risks sooner. These risks can be managed by counseling and guiding industry and, if necessary, adapting regulatory pathways for medical devices. Participants expect that the new MDR will help, as the expectation is that medical devices are more heavily regulated under the MDR in terms of evidence requirements for market entry. The Big Future envisioned by participants in this micro-regime of anticipation is thus that all medical devices fit within a clear pathway to market approval and that information is known in time to change those pathways when necessary.

The international HS tool in this micro-regime is envisioned as a collection of information that can serve as the input for 'high impact' reports, set up thematically. To be useful, they should consider a longer time horizon that includes the earlier phases of development, e.g., pre-clinical developments. The Little Future thus includes devising

a HS system with a longer time horizon, producing reports on trends and most disruptive technologies, and guiding industry through new or existing regulatory pathways.

5.4 Collaborating on horizon scanning to increase efficiency and to stand stronger together ("collaboration")

> *"You know, the medical device industry is global. So, honestly, I don't see why horizon scanning should be based locally. I think that horizon scanning must be an international, centrally managed activity, because the benefits are for everybody. We can centralize the costs, we can centralize the competence, we can centralize the knowledge, the skills, the expertise, with a lot of efficiency gains." (Participant 11, IHSI MDWG, 27-01-2022)*

In the final micro-regime that we identified, the main anticipatory objective is for the participating countries to share skills, experiences, and methodologies. As the quote shows, the participants expect that collaborating on HS will improve efficiency by reducing duplication in information-gathering, allowing countries to benefit from one another's experiences. Moreover, the IHSI MDWG currently consists of countries that represent relatively "smaller markets" for medical devices. In defining stricter national governance provisions, some countries fear that medical device companies might choose not to enter their market. Therefore, these "small" countries feel they need to work together to stand stronger against both international industry and regulatory actors:

> *"The reason why the large countries are not in the working group is that they have set up their own systems. The large countries have put a lot of resources into their own systems, and they are not that eager to change anything for collaboration. Whereas the small countries see that collaboration is efficient. This is the reason why European collaboration on HTA or horizon scanning is driven more by small countries than by large countries." (Participant 3, IHSI MDWG, 19-1-2022)*

Medical devices are framed as international developments and difficult to control at national levels because there is too much information and fragmentation. HS for medical devices is complex and costly, so sharing the workload across participating countries can reduce costs and increase efficiency and expertise. Participants expect to see more incentives for collaboration, in part because of new regulations like the HTAR. Uncertainty is considered inevitable, yet manageable. Participants say it would be more costly not to collaborate, but that collaboration might initially reduce efficiency. Because HS

may mean something different to different member countries, the varying national systems might hinder the overarching goal of reducing the workload. Still, participants are hopeful. They recognize that looking at HS from different perspectives and experiences will improve the tool, because each member organization has different standard operating procedures, and may notice something that the others do not:

> *"Because we look at the product from different perspectives, different views, so in developing a tool, it will reflect most of the relevant aspects that need to be addressed. We should work together, because acting alone we cannot see all the issues, since we all have different experiences." (Participant 13, IHSI MDWG, 13-01-2022)*

Participants hope that by collaborating, they can influence the whole governance trajectory for medical devices. Participants report that much still seems "*skewed*" in the medical devices market, for example the poor collaboration between transnational regulatory agencies and national HTA agencies. They expressed hope that they could resolve this together by boosting their negotiating power and aligning their interests. The Big Future envisioned by participants in this micro-regime of anticipation is thus about standing the participating smaller countries stronger together, improving efficiency and reducing duplication through collaboration, and influencing the whole medical device governance trajectory.

One important aspect of the HS tool is that it must be flexible so that information can be tailored to each member country's needs. Participants envision each country tasking a local team with translating findings to their national setting. Participants say that they would like to collaborate with other organizations, but because the working group is in the initial stages, objectives cannot yet be aligned. The Little Future is therefore about negotiating national needs and wishes, creating an interactive and flexible tool containing all relevant information, preparing for translation to the national context, and reaching out to new participants and collaborating partners.

5.5 Comparing the micro–regimes of anticipation

There are similarities among the four micro-regimes of anticipation identified. In all four, expectations focus on dividing medical devices into categories to deal with vast numbers of emerging technologies. To some extent, the micro-regimes also share participants' belief in the capacity to manage uncertainties, albeit in different ways. In the first micro-regime, it is mainly by prioritization and assessment; in the second, by identifying relevant themes and information sharing; in the third, by identifying the most disruptive technologies and preparing regulatory pathways; and in the fourth, by

gathering all relevant information and finding more collaborating countries to reduce the workload. In addition, both the second and fourth micro-regime encapsulate the belief that the lack of control over the vast number of emerging medical technologies can be managed by increasing collaboration, albeit at a different level, as the second micro-regime is mainly concerned with collaboration at the local level and the fourth with collaboration at an international level.

The micro-regimes differ in several other respects. First, they operate at different levels. The fourth micro-regime is embedded mostly in structures at an international level, such as the European Union. The third micro-regime operates at both international and national regulatory levels, including market approval of medical devices in the EU (international) or in Canada (national), and regulatory market surveillance at national level. The first and second micro-regimes operate at national, regional, and facility level, as context-specific information is needed to conduct HTA and inform procurement. The different levels represent differing levels of complexity, uncertainty, and preferred actions in the present.

Additionally, we identified differences in relationships with other stakeholders (like industry), in framings of medical devices, in intended time horizon and scope, and in visions of the future. Concerning the relationships to other stakeholders in the first micro-regime, there are predominantly worries about distrust from industry, whilst in the third micro-regime a helpful dialogue with industry seems to be anticipated. There are also differences in the way the medical devices are framed in the four micro-regimes: both the first and third micro-regimes frame medical devices in terms of expected impact, but the first micro-regime defines this impact by the cost and quality of the healthcare system and the third in terms of risk to the regulatory system. The expected time horizon of the first and second micro-regimes is shorter compared to the time horizon in the third, while the expected time horizon in the fourth should ideally be both short and long to meet all national needs. There are also differences in expected scope, with the first micro-regime focusing on impact in defining the expected scope, the second on defining important themes, the third on level of disruptiveness, and the fourth on identifying as wide a scope as possible.

The differences between the micro-regimes of anticipation show that the same anticipatory practice (the international HS tool) is expected to live up to a variety of expectations. Embedding all these expectations could create tensions going forward. In addition to time and resource constraints, which make it difficult to live up to all expectations at once, the specific differences described above have implications for the future governance of medical technology.

5.6 HTA as dominant micro-regime

Not all micro-regimes carry the same weight in the medical devices working group. We can illustrate this with the survey results which asked participants to rank various purposes of the horizon scan according to perceived importance (Table 3). Some purposes are considered somewhat more important than others. The purpose to "identify and filter information on medical devices for HTA" was considered most important by the respondents. This purpose largely corresponds to the first micro-regime (HTA). The purpose "to prioritize topics for research/additional evidence generation" can also be linked to the first micro-regime and was ranked third most important. The second most important purpose correlates largely with the second micro-regime (facilitation), namely "to inform regional decision-makers/health services/hospitals" and "to inform procurement." The results of the survey and how they relate to the micro-regimes show that the micro-regimes differ in their importance to the working group. As we have described, the first micro-regime is based largely on the HS framework for pharmaceuticals. This – we expect – will shape the form and function of the tool in the making.

Table 3: Ranking of purposes by participants in the International Horizon Scanning Initiative Medical Devices Working Group

Rank	Expected purposes	Average ranking on a scale from 1 (most important) to 9 (least important)	Corresponds to micro-regime
1	To identify and filter topics or themes for HTA	3.2	1st MR: Horizon scanning to identify and filter topics for HTA
2	To inform regional decision-makers/health services/hospitals	3.4	2nd MR: Horizon scanning to facilitate procurement
3	To prioritize topics for research/additional evidence generation	4.5	1st MR: Horizon scanning to identify and filter topics for HTA
4	To allow for earlier access to treatment	4.9	All four MR
5	To inform decisions related to regulation	4.9	3rd MR: Horizon scanning to inform decisions related to regulation
6	To inform procurement	5.0	2nd MR: Horizon scanning to facilitate procurement
7	To share skills, experiences, and methodological approaches	5.0	4th MR: Collaborating on horizon scanning to increase efficiency and to stand stronger together
8	To allow for early dialogue with industry	5.2	3rd MR: Horizon scanning to inform decisions related to regulation

HTA: Health Technology Assessment, MR: Micro-regime

5.7 Favoring predictive approaches to anticipatory governance

Each of the four micro-regimes we identified can be related to the first and second theoretical approaches to anticipatory governance, which aim to predict the future and strategically build capacity for the future, respectively. The dominant expectation of the first micro-regime is that the future can be predicted. The second, third and fourth micro-regimes see more irreducible uncertainties in the future but believe that it is possible to prepare for that future by working together. This favoring of the first and second theoretical approaches to anticipatory governance, i.e., the belief that the future can be predicted and/or prepared for, means that our participants generally expect that the future can be made (partly) knowable and manageable. Moreover, prediction and preparation are favored over imagining diverse futures or critically interrogating the assumptions underpinning future-related claims. Uncertainties are interpreted as risks and inconclusive evidence, and are deemed solvable using processes, standards, and frameworks. There is, at present, no vision of a wider set of more diverse futures or explicit reflection on the implicit assumptions and political tensions, which are more common in the third and fourth theoretical approaches to anticipatory governance. The focus of the IHSI MDWG is on the practical processes of visualizing the tool. In other words, the fact that participants favored the first and second approach to anticipatory governance shows that the working group approached the future with a rather conventional, technocratic approach.

5.8 Engagement and integration between stakeholders

In most anticipatory governance approaches, engagement and integration between different stakeholders are seen as important for building the capacity for the future. An example in our case study is the engagement between HTA and regulatory agencies. Participants noted that there are major differences between the knowledge practices of these groups of stakeholders. Participating organizations that are predominantly HTA-oriented say they are not able to make statements about regulatory matters, and vice-versa. Still, in discussions between the IHSI MDWG organizations, participants also say that there is synergy between HTA and regulatory regimes, and that the two should work together more often. For instance, participants with a regulatory background say that working together is important, since the regulatory bodies set some of the "proper" evidence requirements for the clinical evidence that is used in HTA. Furthermore, because regulatory bodies typically have more interactions with industry, collaborating may help to overcome difficulties obtaining the relevant information from industry in the HTA micro-regime.

The micro-regimes that we identified did not, however, focus to any great extent on engaging with a wider variety of stakeholders outside the IHSI MDWG. Many actors

are (currently) absent from the working group, including industry, healthcare providers, and patients. When the working group did discuss matters with a wider set of stakeholders, the participatory component of the dialogue about the future was more or less absent and their opinion was used mainly to increase the predictability of a deterministic future rather than to diversify the futures considered. Other stakeholders are engaged after the information has already been gathered and even then, there are discussions about how far the information should go public and who should and should not have access to it.

6. Discussion

In this article, we identified four micro-regimes of anticipation in the expectations of participants of an anticipatory practice in the domain of healthcare governance. We showed the dominance of the HTA micro-regime, which can be attributed to the existing reference framework, i.e., HS for pharmaceuticals. In addition, we demonstrated that our participants generally expect that the future can be made knowable and manageable. As of yet, the working group did not explicitly reflect on the broader political and performative aspects of the international HS tool. Finally, we showed how engagement and integration between stakeholders (notably, HTA and regulatory agencies) could alleviate some of the tensions identified. However, we also observed the absence of various other relevant stakeholders in this particular working group.

Our study has both theoretical and practical relevance. Theoretically, we combine the anticipatory governance framework with the concept of micro-regimes of anticipation. This explicit combination is a novel approach that allows us to conceptualize the smaller level of day-to-day agendas and practices of anticipatory governance. Our study applies these concepts to analyze day-to-day practices in the early stages of an international collaboration on HS in the context of healthcare governance. To our knowledge, the anticipatory governance framework has not been applied in this early stage before, nor has it been used in research on HS. In the early stages of a collaboration, what the participants hope the anticipatory practice *will do* can be captured in their expectations. Our access to these early expectations thus allowed us to capture the "anticipation of the anticipatory practice." The concepts of Big Futures and Little Futures are especially helpful here. They show how expectations about Big Futures in the micro-regimes lead to practices in Little Futures and vice-versa, i.e., how everyday practices relating to the Little Futures of the HS tool allow for or undermine Big Futures.

Moreover, we have shown that the micro-regimes tend to follow the more strategic and predictive theoretical approaches (1 and 2) to anticipatory governance (see table 2). This is common in policy practice, as policy instruments often target value-neutral and practical outcomes (Muiderman et al., 2022). The aim of producing outcomes that are practical in policy contexts means that the pluralistic and critical tendencies of theoretical approaches 3 and 4 are often considered not suitable. Our findings thus show how anticipation in this field is interpreted in a traditional, positivistic way, as something that allows one to predict and prepare for *the* future. The pluralistic and critical approaches are rather rooted in ideas of "post-normal science." In their seminal article on post-normal science, Funtowicz & Ravitz (1993) argue that traditional science methodologies are sometimes ineffective, especially in situations where uncertainties and/or decision stakes are high. In those circumstances, science requires an extended community to exercise quality assurance. Our findings seem to support this line of argument, as they imply that engagement between the stakeholders in the IHSI MDWG could help unearth some of the tensions in the governance of emerging medical technologies. We believe that such tensions call for an amplification of the more pluralistic and reflective theoretical approaches to anticipatory governance.

It should be noted here that the IHSI MDWG is a relatively young organization, as such the micro-regimes of anticipation and their relative dominance may (or may not) change over time as the organization becomes more mature. Although an in-depth analysis is outside the scope of this article, it is worthwhile to refer to the literature on organizational institutionalism here (e.g., Owen et al., 2021) as it helps gain insights into how horizon scanning and anticipation are linked to and located within the particular organizational and institutional context of the institutions involved in the anticipatory practice. We believe that this provides direction for future research in other organizational contexts, as horizon scanning can be undertaken for many reasons outside of the medical technology and health care context (e.g., McDowall 2012). The institutionalization of different organizational logics or micro-regimes of anticipation might change over time, for instance as the IHSI MDWG becomes more established. This theoretical standpoint provides direction for future research on the institutionalization of horizon scanning over time at the European and national levels. Another point for future studies is to apply our theoretical framework at other stages in the medical device lifecycle. As mentioned in the introduction, we have focused our analysis on an anticipatory governance practice aimed at the earlier stages of this lifecycle before large-scale use. A critical note is that our analysis focuses on predominantly European institutions within the Global North. Although the IHSI MDWG is inclusive of, as they say, the "smaller countries" within this context, the collaboration still will most likely focus on countries with similar levels of development and policy contexts. This

discourages participation of countries that do not share this 'Eurocentric' approach. It would be interesting to see whether a focus on governance practices at other moments or on other actors and institutions, such as in non-western contexts, involved in the medical device lifecycle may foreground other micro-regimes of anticipation and/or other configurations of relative dominance.

Our article also has practical value for the governance of emerging medical technologies. To begin with, although expectations in anticipatory practices are speculative, they can be performative in privileging certain visions of the future over others. In this case, for example, the dominant framing of medical devices through experiences with pharmaceuticals shapes the linear way in which the tool is envisioned and developed (the Little Future). The linear framing of the future is represented, for instance, in the way that the medical device lifecycle is envisioned by IHSI MDWG (see Figure 1). If medical devices typically develop more iteratively, envisioning the HS tool in a successive manner may not suit all medical devices; examples include minimally invasive surgical devices and diagnostics based on artificial intelligence, which develop iteratively and are difficult to study in blinded and randomized clinical trials, or technologies that involve a clear learning curve between user and technology (Drummond et al., 2009; Tarricone et al., 2017).The evidence base of emerging medical technologies often contains conflicting evidence at different stages of development. Linear representations of medical technology development are criticized more broadly in literature on Science and Technology Studies (STS), as they often fail to capture elements such as "*surprise, radical contingency, or simply the messy interplay between humans and their technological culture*" (Konrad et al., 2016, p. 16.). Though not unique to medical devices, non-linear development and conflicting evidence is something that will need to be reflected on and dealt with in collaborations on HS for such devices. If not, this could affect the usability of this tool for medical devices.

Zooming out to the Big Future allows us to also reflect on the more normative implications of this framing, i.e., which futures should be envisioned. If reimbursement of medical technologies is made to depend largely on whether sufficiently robust evidence is available, the way in which this is framed will eventually have a bearing on patient access to medical technologies. If ways of thinking about evidence requirements for pharmaceuticals are entrenched, such framing could affect the reimbursement decisions and uptake of medical devices, which do not fit well into that linear approach. This touches upon wider discussions about deliberative or circular HTA for medical devices, where it is argued that HTA of medical devices should consider a more dynamic and iterative approach that acknowledges the specific characteristics of medical devices, as opposed to the more sequential and linear nature of traditional HTA that

typically requires a "steady state" period for evaluating the technology (Drummond et al., 2009; Tarricone et al., 2017; Ni et al., 2020). The discussions around deliberative or circular HTA resemble discussions around the precautionary principle (PP) (e.g., Mittelstadt 2015, Lysaght 2022, Philbrick, 2010). Our analysis also illustrates how the linear approaches and framings of emerging medical devices are shaped by existing institutional arrangements in the governance of emerging medical technologies—with expectations based on existing regulations like the MDR and on experiences with HTA. These expectations actively shape the governance of emerging medical technologies itself. Furthermore, such framing of emerging medical technologies favors those companies that have the capital to develop 'sufficiently robust' evidence as well as those governments that have the resources available to assess such evidence. Lastly, as the quote in our description of the collaboration micro-regime (chapter 5.4) reads, collaboration is deemed necessary as "*the medical device industry is global*", and international collaboration on horizon scanning could "*centralize the competence, the knowledge, the skills, the expertise, with a lot of efficiency gains*" (Participant 11, IHSI MDWG, 27-01-2022). Those countries for which such international collaboration is not viable do not currently benefit from such centralization of knowledge and skills, whilst still dealing with a global medical device market that becomes increasingly complex. Although an in-depth analysis of potential consequences is outside of the scope of this article, it is possible that an imbalance in knowledge and skills will be mirrored by an imbalance in abilities to prepare for emerging medical technologies and their consequences on the health care system. We consider it crucial for international collaborations such as the IHSI MDWG to reflect on these implications.

Our findings also help question the practical implication of a relative absence of the more pluralistic, third theoretical approach to anticipatory governance of emerging medical technologies. Acknowledging pluralistic futures encourages stakeholders to explore unintended consequences and reflect on their underlying assumptions (Bengston et al., 2012). The pluralistic approach is more likely to unearth any underlying assumptions and lay bare the relations of power through which ideologies of the future are brought into the present (Facer & Sriprakash, 2021). Specific practical examples of different anticipatory practices to experiment with include visioning, an exercise aimed at creating a shared vision of the future based on shared values and purpose, and scenario workshops, which generate a set of stories or narratives of plausible futures intended to help decision-makers and others build adaptive capacity that makes their systems more resilient through preparing for a diverse set of alternatives (Muiderman et al., 2020). The absence of the more critical theoretical approach to anticipatory governance highlights that there is currently no explicit reflection on the visions of the future and their underlying assumptions in our case study. By failing to reflect on the "openness

of the future" and the political and performative aspects of the international HS tool, participants risk ignoring the socio-political constructive dimensions that are inherent to socio-technical systems like medical technology development (Uruena, 2021, p. 279). Innovation, medical technology development, and governance are not just a technical but also a socio-political matter. Including or excluding medical technologies from the HS tool will *do* something to these technologies, as they may be identified, classified, assessed, procured, distributed, regulated, guided, shared, or dismissed. Our findings point to the importance of critical reflection on these and other implications of the HS tool, and we believe that collaborations such as the IHSI MDWG should offer scope for such a "reflexive space" (Wiig et al., 2021).

Most micro-regimes in our analysis did not focus on anticipation of engagement with a wider variety of stakeholders. This is interesting given the widespread recognition of patient and public engagement in healthcare decision-making (e.g., De Graaff et al., 2021). From an anticipatory governance perspective, one could argue that stakeholder values that are not included may not be considered. This begs the question of who in the present has agency to determine future problems and actions through the international HS collaboration. On the other hand, our findings also point to the complexity of such involvement, due to conflicting values and knowledge practices between stakeholders and differences in day-to-day agendas. Inviting a wider variety of stakeholders will probably increase the number of Little and Big Futures considered and produce additional tensions. We therefore believe it important to document and reflect on these different futures, and to work towards presenting or representing an inclusive and diverse array of stakeholders' perspectives when engaging in, and developing, anticipatory governance practices. Doing so might avoid certain futures being unaddressed and help participants understand the various and sometimes conflicting futures that can be acted upon (Dolez et al., 2019).

Finally, our findings should be interpreted within the empirical context of our case-study. Firstly, the case-study existed predominantly of organizations from relatively "smaller countries". As we describe in chapter 5.4, these self-acclaimed smaller countries partly wish to collaborate internationally on HS for medical technologies because they worry that when standing alone, they may be by-passed in medical device introductions. Therefore, the participating organizations hope that collaborating internationally enables them to stand stronger towards both international industry and regulatory actors. Our findings should thus be interpreted within the context of relatively smaller-scale governing actors. It could, for instance, be the case that these countries favor prediction and preparation over pluralizing and problematizing, and lean on a reference framework of pharmaceuticals in doing so, because of this relatively more vulnerable

position. Although some research already alludes to how most HS initiatives for medical devices focus on similar goals like prioritization, HTA, procurement, etc. (e.g., Ormstad et al. 2023), more research on HS collaborations in the context of medical devices would be useful to further situate our findings. Secondly, our case-study centers on a collaboration of actors engaged in horizon scanning for medical technologies situated in the Global North. This focus allowed for an in-depth analysis of practices in Western anticipatory governance of medical technologies. At the same time, it excludes analysis of anticipatory governance of medical technologies outside of this context, as we do not capture the expectations of actors outside the scope of our case study. There are, therefore, limitations to the plurality of perspectives captured by our research. The identified micro-regimes are influenced by specific, Western notions of what constitutes good governance, including ideas around HTA and regulation. Including a Global South perspective, for example, may have introduced another understanding of such governance (Mitchell & Chaudhury, 2020). As is shown by Mitchell & Chaudhury (2020), our study context influences and shapes the type of actions deemed appropriate for the anticipatory governance of medical technologies. It is important to interpret our results in light of these limitations.

7. Conclusion

Our findings underscore the importance of anticipatory pluralism and critical reflection in anticipatory governance, allowing a broad range of futures to be open to scientific and public scrutiny. The governance of medical technology through HS has many possible futures. We have described a few of these, such as a future based on experiences with HS for pharmaceuticals, and a future in which the predictive and strategic approaches to anticipatory governance dominate. We also reflected on alternatives, such as futures in which more stakeholders are invited, collective imagination and critical reflection dominate, and uncertainties are embraced rather than minimized. Our analysis reveals the continuous interaction between actions and futures, with the future of governance of medical technologies being based on what these stakeholders expect and do not expect, which experiences, knowledge practices, and *imagined* futures are included and which ones are dismissed, and who is invited and who is not. As such, we see a need for anticipatory practices to become more reflexive about the consequences of future visions, the assumptions behind them, and the implications for the actions needed in the present. This would increase the relevance and value of the policy tools developed for the governance of emerging medical technologies.

CHAPTER 4

Anticipatory Practices Of Private MedTech Governance Actors And The Public-Private Anticipatory Loop

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In a Loop of Anticipation: The Anticipatory Practices of MedTech Industry Actors

Abstract

The (anticipatory) governance of medical technology (MedTech) involves different types of actors. An important but under-theorized actor within the governance network are the companies that develop and market MedTech. In this paper, we use an anticipatory practice (AP) lens to critically reflect on the APs of mainly Dutch MedTech industry actors. We distinguish three categories of APs, provide examples, and describe complicating factors. Overall, we show that the APs of private industry and public governance actors are highly interdependent. We reflect on these interdependencies and offer the theoretical concept of an 'anticipatory loop' between public and private governance actors. We discuss the need for public governance actors to be aware of the uncertainties exacerbated by such an anticipatory loop and reflect on the complexities of an emerging desire to step out of this loop and anticipate together in an open and reflexive space. We make the case for an approach to the AG of MedTech that includes APs aimed at creating reflexive space for dialogue in addition to more long-term, standardized procedures.

1. Introduction

The governance of medical technology (MedTech[4]) involves different types of actors. In the European Union (EU), designated organizations called Notified Bodies (NBs) assess the conformity of MedTech innovations with standard regulations before they are certified and granted market access. At national and regional levels, various actors oversee the reimbursement of MedTech, including Health Technology Assessment (HTA) agencies, hospitals, health insurers, municipalities, patients, and others. An important but under-theorized actor within the governance network is the MedTech industry actor, i.e., the companies that develop and market MedTech. Governance activities, including recent European regulations such as the Medical Device Regulation 'MDR' (EU, 2017a), the HTA Regulation 'HTAR' (EU, 2021b), or the Artificial Intelligence Act 'AI ACT' (EU, 2024), influence MedTech industry actors, by fostering certain technological innovations and not others. At the same time, the development of innovative technologies shapes the governance required, as evidenced by the need to reassess the AI ACT after the introduction of ChatGPT (Helberger & Diakopoulos, 2023).

A growing body of literature discusses the ways in which public governance actors prepare for the future of innovative technologies by engaging in anticipatory practices (APs), such as 'horizon scanning', 'health technology assessment', or 'scenario workshops' (Michels et al., 2024). Such a prospective approach to the governance of medical and other technologies is theorized under anticipatory governance (AG), both as an analytical tool (Anderson, 2007, 2010) and a more normative framework (Barben, 2008). AG refers to governance processes that use anticipation to prepare for uncertain futures (Konrad & Alvial-Palavicino, 2017; Muiderman et al., 2020). APs are tools that help engage with such uncertain futures, deliberate about uncertainties, and guide action in the present. Through such engagement with the future, APs can performatively shape the future, by framing issues, shaping perceptions, and legitimizing decisions (Gond et al., 2015; Hutchby, 2001). APs 'make' certain futures present (and not others) and produce logics of legitimation for ways of approaching those futures (Anderson, 2010). Furthermore, as APs often involve choices between different ways of seeing the

4 As our study focuses on the European context in general, and the Netherlands more specifically, we adopt the rather wide categorization of MedTech as given by MedTech Europe, the European trade association for MedTech, namely: Medical devices (products, services or solutions that prevent, diagnose, monitor, treat and care for people), in vitro diagnostics (non-invasive tests used on biological samples to determine the status of a person's health), and digital health (tools and services that use information and communication technologies (ICTs) to improve prevention, diagnosis, treatment, monitoring and management of a person's health and lifestyle (MedTechEurope, 2022).

future and different actions in the present, they provide interesting insight into the politics of governing the future (Muiderman et al., 2020).

However, it is not only public governance actors that prepare for the future through APs. Private industry actors may also do so, for example when anticipating the effects of changing European regulations (Hautala & Ahlqvist, 2022; Hendricks et al., 2023; Minkkinen, 2018; Visscher et al., 2021). Nevertheless, the AG literature has paid relatively little attention to the specific APs of (MedTech) industry actors (Alvial-Palavicino & Konrad, 2019; Pollock & Williams, 2010). As a result, not much is known about the position and practices of (MedTech) industry actors within the AG framework. In this paper, we explore the APs of (mainly Dutch) MedTech industry actors. We aim to show how MedTech industry actors navigate the (changing) governance framework of MedTech and how their APs co-construct the AG of MedTech. Our analysis particularly highlights how the APs of private industry and public governance actors are highly interdependent. We reflect on these interdependencies in the discussion, including theoretical implications for AG and practical implications for the governance of emerging MedTech.

2. Conceptual Approach: An Anticipatory Practice Lens

Conceptually, our analysis adopts an AP lens. In the literature on the governance of emerging (medical) technologies, the future is a pervasive theme (Alvial-Palavicino, 2015). APs provide a way to see how this future is anticipated, through expectations embedded in socio-material practices. Through such expectations, they can performatively shape this future (Alvial-Palavicino & Konrad, 2019; Konrad & Alvial-Palavicino, 2017; Urueña et al., 2021). There is a heuristic variety of APs, in line with an analytical diversity of approaches to AG (Muiderman et al., 2020; Urueña et al., 2021). APs range from more predictive to more reflexive approaches and can be placed on a spectrum from more to less formalized and institutionalized. Examples of more formal, predictive APs include technology assessment and econometric modeling exercises, while more formal, reflexive APs include simulation games and integrative deliberation (Muiderman et al., 2020). More informal (or implicit) APs are approaches without standard methodologies and processes, such as making informal calls and attending events (Orsato et al., 2017) or choosing in which journal to publish an article (Alvial-Palavicino & Konrad, 2019)— their informality, however, not limiting the extent to which these APs can shape the future.

The literature on APs by industry actors has mostly focused on practices related to the development and promotion of innovative technologies, often referred to as 'industry foresight', examples of which include scenario planning, the Delphi method, and horizon scanning (Hautala & Ahlqvist, 2022; Postma et al., 2007). Such industry APs tend to have shorter time horizons compared to APs by public actors and appear to be aimed primarily at competitive advantage (Saukkonen, 2016). Recently, more ethically oriented approaches have also emerged, including 'ethics by design', which uses anticipation within the engineering process as a way to prevent or identify ethical issues early on (Umbrello et al., 2023). More critical literature includes the work of Pollock & Williams (2010), who have explored how consultancies and intermediaries can act as promissory organizations within the industrial sphere, producing 'future knowledge' that influences the design of technologies. In addition, Harmon et al. (2023) have shown how industry actors can use APs to provide 'prospective legitimation' of innovations to investors, linking unproven ideas to desirable future profitability.

In this paper, however, we move away from the role of industry APs in the development and promotion of specific technologies, to zoom in on the relationship between industry APs and MedTech policymaking. The ways in which the APs of industry actors co-shape policy remain understudied empirically. Literature exists on how public governance actors shape policies around emerging technologies by engaging in APs (e.g., horizon scanning, technology assessment, or scenario workshops) (Budde & Konrad, 2019; Michels et al., 2024), but relatively little research has focused on the position and practices of industry actors. Visscher et al. (2021) show how industry actors may respond to the APs of public governance actors with orchestration activities, building networks and strategic alliances to share knowledge and jointly anticipate future requirements. Munn (2022) describes the term 'ethics washing', to show how industry actors sometimes respond to the ethics discourse that is prevalent within public governance activities by emulating this ethics language in their APs, as a way to avoid regulation. Another strand of literature looks at how industry actors use lobbying as an AP to influence policies proactively (Granjou et al., 2017; Hendricks et al., 2023; Minkkinen, 2018). Such literature emphasizes that governance is a two-way process (Alvial-Palavicino, 2015), where attempts by public governance actors to govern emerging technologies generate a response from private industry actors and vice versa, together co-shaping innovation policy.

Scholars looking into the ways in which expectations or anticipations shape policies have highlighted the importance of 'space', be that for experimentation, collaboration, or exploration. Alvial-Palavicino (2015) emphasizes how APs take place in specific spaces and, at the same time, may create space (both literally and metaphorically),

for example, materializing expectations into grant applications which in turn create a protected space for experimentation. The extent to which an actor has space available (in the metaphorical sense) to anticipate has been termed 'anticipatory agency', i.e., *"the strategic ability to construct feasible targets for the future [...], and to implement actions on this basis"* (Ahlqvist et al., 2012, p. 824). Kuhlmann et al. (2019) highlight the importance of space in their description of 'tentative governance', which they argue aims to create space(s) for exploration and learning between public and private actors, in a dynamic balancing act. An example of such a space for collaborative learning is the creation of experimental pilot projects, a popular approach within AG (Ryghaug & Skjølsvold, 2021). Such experimental APs have the ability to create 'reflexive space' (Wiig et al., 2021), conceptualized as physical or virtual platforms that can bridge different stakeholders, in which reflexive dialogue can occur (p. e1682).

The above shows that APs are multifaceted and provide an interesting entry point into understanding AG. Alvial-Palavicino & Konrad (Alvial-Palavicino & Konrad, 2019; Konrad & Alvial-Palavicino, 2017) note that it is important to examine APs, studying their role within the broader governance of and by anticipation. Governance of anticipation refers to the ways in which anticipatory methods themselves are governed, such as through guidelines by HTA agencies, and governance by anticipation refers to the use of anticipatory practices as tools for governance, to shape the present based on imagined, expected or projected futures, such as through conducting early HTA or horizon scanning—the two being obviously interrelated (Konrad & Alvial-Palavicino, 2017). Uruena et al. (2021) similarly argue that for APs to become tools for 'responsible' innovation, their socio-epistemic relations and emergent heuristics should be investigated. Our study contributes to the critique of the performative role of representations of the future in the governance of innovation (Urueña et al., 2021) by reflecting on how the governance of the future by public governance actors interacts with the governance of the future by private MedTech industry actors. We employ an AP lens so as to critically reflect on APs of MedTech industry actors as they navigate the (anticipatory) governance of MedTech, interact with APs from public governance actors, and (together) search for reflexive space amidst uncertainty.

3. Data Collection And Analysis

Our study is based on (non-)participant observations and semi-structured interviews. Our observations covered 3 public events for MedTech industry stakeholders in the Netherlands. Our first observation site was the 'World of Health Care' event organized by the Dutch government, specifically the Dutch diplomatic network and Task Force

Health Care, in September 2023. The aim of the event was to foster collaboration in the Dutch life sciences and health sector. The annual event targets Dutch life sciences and health companies as well as foreign healthcare decision makers and consisted of workshops and plenary sessions. The second event we observed was the MDR/IVDR event in March 2024, hosted by 'Care for Innovation', a collaboration between five government organizations in the Netherlands, namely the Ministry of Health, Welfare and Sport (VWS), the National Health Care Institute (ZIN), the Dutch Healthcare authority (NZA), the Netherlands Enterprise Agency (RVO) and main Dutch health research funding agency (ZonMw). The event's aim was to share experiences and gain insights on the MDR and IVDR, similarly through workshops and plenary sessions for MedTech industry stakeholders.

The third event we observed was a MedTech Netherlands (MTN) meeting on data practices and AI, held in June 2024 for MedTech stakeholders, including healthcare organizations, MedTech companies, governments, and others. The aim of the event was to discuss recent developments related to data and AI in the MedTech sector, such as the AI Act (EU, 2024), the regulation on the European Health Data Space (EHDS) (EU, 2022), and the Data Act (EU, 2023). During the first two events, we deliberately left the focus of our observations open. For the third event, when our analysis was already further developed, we focused our field notes on discussions about APs, including expectations regarding recent European regulations, practices to deal with uncertainties, and references to APs of governing agencies. Whereas the first two events were particularly useful for developing synthesizing concepts that helped shape the focus of our interviews (discussed below), this last event allowed us to dive deeper into building hypotheses from our data, such as the occurrence of an "anticipatory practice loop" between public and private governance actors.

In addition to our observations, we conducted semi-structured, online interviews with 15 MedTech industry actors. All interviewees were located in the Netherlands except for 1 in Germany, namely interviewee 7, who moved to a start-up located in Germany, reflecting the dynamic nature of the European MedTech market. As the (anticipatory) governance landscape for MedTech is organized largely at the European level, and Germany and the Netherlands are both key markets in the MedTech landscape (MedTechEurope, 2022), we believe this interview adds to the purposes of this article. We included actors from different strata of industry to obtain a heterogeneous perspective on the APs of MedTech industry actors. Participants self-identified as working for either a start-up, scale-up, multinational, consulting, or umbrella organization (Table 1). As the boundaries between these categories can be somewhat fluid in practice, some interviewees could be placed in more than one category. As many participants referred

to the complex role of Notified Bodies (NB) as a private actor that performs a public, regulatory function, we also included one interview with an NB.

The interviewees covered interviewees' experiences with the (changing) governance landscape of MedTech. All participants were asked to reflect on experiences and expectations surrounding recent European regulations, experiences and expectations surrounding evidence generation, and experiences and expectations surrounding governing actors (such as NBs, HTA agencies, national governments) with respect to MedTech governance. The interviews were held in Dutch, involved a single interviewer and interviewee, lasted approximately 1 hour, and took place between December 2023 and June 2024.

Table 1: Interviewees categorized into industry actor type (self-identified)

Background	Interviewee
Start-up	7, 9, 11, 13
Scale-up	6, 12, 15
Multinational	5, 8, 10, 14
Consulting	1, 2, 4, 12
Umbrella organization	1, 2
Notified body	3

Interviews were recorded using Microsoft Teams and transcribed verbatim. The transcripts were analyzed by the first author and reviewed by the other authors. We took an abductive approach to our analysis, iteratively building on our emerging data and the AP lens. We first developed codes inductively, identifying themes in our discussions, and reflecting on the literature described in the conceptual framework, references to the APs of industry actors as well as of governing agencies, and expressions related to creating reflexive space and experimentation. (See Supplementary Appendix, Table 1). A second round of coding specifically identified formal and informal APs related to 'grasping the future', 'undertaking the future', and 'collaborating with public governance actors on the anticipated future', (See Supplementary Appendix, Table 2). The analysis was further refined through repeated discussions among the authors as well as through discussions with researchers within our research network (during department meetings) and outside of our research network (at several conferences).

To situate our study context, the European market is the second largest MedTech market following the United States (MedTechEurope, 2022). Germany accounts for the highest percentage of the European MedTech market, namely 27%, and the Netherlands accounts for 5%. Small and medium-sized companies (including start-ups and scale-ups)

account for 95% of the MedTech industry within Europe. Both the Netherlands and Germany follow EU regulations, in the Netherlands the Dutch HealthCare authority (NZA) and Health and Youth Care Inspectorate (IGJ) oversees compliance with these regulations (IGJ, 2023; NZA, 2021), and in Germany the Federal Institute for Drugs and Medical Devices (BfArM) (BfArM, 2024). In the Netherlands, most MedTech is reimbursed through the Zorgverzekeringswet (Health Insurance Act) or the Wmo (Social Support Act). (Bruins, 2019). Reimbursement of intramural (within the hospital) care is mostly decided by hospitals, while decisions on extramural care involve both health insurers and municipalities. The reimbursement of MedTech in Germany involves the Federal Joint Committee (G-BA), which decides on the inclusion of technologies in the statutory health insurance scheme (Eckhardt et al., 2023). Reimbursement decisions are influenced by HTAs conducted by the Institute for Quality and Efficiency in Health Care (IQWiG).

Finally, our study received ethical approval from the Erasmus School of Health Policy and Management (ETH2324-0139). All interviewees gave their written informed consent before taking part in the study. The study took place in the context of our longstanding academic collaboration with ZIN and was partly funded by ZIN. Researcher independence is guaranteed in the written partnership agreement between ZIN and our research faculty. Finally, on the topic of data analysis, the data were interpreted through an STS-informed, critical lens on the ways in which APs may contribute to certain futures whilst circumventing others. Researcher reflexivity was sought through data triangulation, the use of a conceptual framework, member checking of quotes used, and presentations within our research group and at academic conferences. However, in terms of positionality, the analysis is informed by the authors' ethical concerns about the implications of the identified APs for equity, accountability, innovation, transparency, and safety in the future governance of MedTech.

4. Results

In this section we describe the APs we identified from our data. We first describe two categories of APs engaged in by MedTech industry actors, namely APs aimed at *grasping* the anticipated future and APs aimed at *undertaking* the anticipated future, providing examples and summarizing the complications participants experienced when engaging in these APs. We then describe a third category of APs, namely those in which private MedTech industry and public governance actors *collaborate* on the anticipated future. We describe how this last category of APs seemed to have emerged from a desire to create a reflexive space in which both actors could deliberate together on

uncertainties in the governance of MedTech and reflect on complications as voiced by participants. Table 2 provides an overview of all three categories of APs identified.

Table 2: The anticipatory practices of MedTech industry actors

Anticipatory practice aimed at	Grasping the anticipated future	Undertaking the anticipated future	Collaborating with public governance actors on the anticipated future
Description	Interpreting governance activities from public governance actors	Implementing and circumventing governance activities from public governance actors	Creating reflexive space to interpret and implement together, through (in) formal conversations and experimental approaches
Examples	Developing playbooks for or audit logs of new regulations, organizing workshops, developing regulatory expertise	Reorganizing, hiring lawyers and consultants, setting up clinical studies, leaving the European Union	Organizing and visiting networking and information events, discussing with public governance actors (e.g., early value conversations, FDA ombudsman), setting up sandboxes, pilots or roundtables

4.1 Grasping the anticipated future

A first category of APs shared by our participants seemed to be aimed at grasping the anticipated future, in terms of interpreting the expectations of public governance actors, closely monitoring public governance actions (such as new European regulations) in anticipation of changes, ensuring that everyone internally is aware of anticipated changes, and exchanging expectations with other industry actors on these issues. A typical example of an AP aimed at grasping the anticipated future was found during our observations, when an industry actor mentioned how their company had closely followed discussions related to the AI ACT and created an audit log of all changes made by regulatory actors, "*this gives a sense of control and security.*" (Observations, consulting, 11-06-2024). A similar example was the implementation of 'playbooks' detailing the steps required to implement regulations: *"We analyzed the whole MDR and wrote playbooks for all its elements. It's of course a little funny we call them playbooks, but that is what they are, there are rules to the game that we play, and you have to interpret them in order to implement them."* (Interviewee 10, multinational, 22-04-2024). Participants also mentioned engaging in 'horizon scanning' for new rules and regulations, but said that this was more short-term and focused than the horizon scanning activities of public governance actors. As one participant mentioned: *"You inevitably have to think around your own products. So, we are looking to the future, but this is a limited exercise*

in terms of size and breadth. You expect the broader view from the policy maker" (interviewee 5, multinational, 14-03-2024). Yet another common example was found in how participants organized internal workshops, aimed at *"developing awareness within the organization of the changes that are taking place and what it will require of everyone."* (interviewee 8, multinational, 08-04-2024). Overall, it seems that grasping APs are aimed at understanding what public governance actors expect from MedTech industry actors in the anticipated future, providing a sense of control and a general level of awareness, and are generally relatively short-term and limited to industry actors' own products.

Participants argued that such grasping APs were complicated by several factors. First, they experienced geographic differences in how public governance actors expected the rules and regulations to be interpreted. Participants often likened the interpretation of regulations to game rules and explained that these game rules could be different for each EU member state. This meant that *"what it will require of everyone"* differed per country, and sometimes also within countries. This sentiment was echoed by our participant working at an NB, who mentioned that there was still some ambiguity in the consistency between different NBs, although this seemed to be improving as more experience was generated (interviewee 3, 21-02-2024). These geographic differences resulted in "*the European business case not being so straightforward."* (interviewee 9, start-up, 12-04-2024). It was argued that this was especially difficult for start-ups, who had less *"cash runway"* (interviewee 7, start-up, 03-04-2024) available, i.e., less time and money available to fully grasp all different expectations.

Second, grasping APs were complicated by the fact that policies and regulations were seemingly constantly changing, likened to '*moving goalposts'* (observations, consulting, 11-06-2024). Concepts were sometimes explained differently in new regulations compared to older ones. For example, MedTech industry actors discussed inconsistencies between definitions in documents pertaining to the EHDS and the Data Act (observations, 11-06-2024). To cope with different expectations, changing goalposts and inconsistencies, industry actors said to need each other, using the power of network or "*hive mind"* (observations, consulting, 11-06-2024), so that they could fill gaps left by public governance actors, share expectations, and learn how to navigate the governance framework together. There was a limit to such sharing of information, however, because of competition between industry actors.

Third, participants argued that such grasping APs often felt like *"invisible work"* that felt "*underestimated*" by public governance actors (interviewee 5, multinational, 14-03-2024). Start-ups seemed to be particularly complicated by this perceived underestimation. One start-up shared that it seemed that public governance actors assumed

that companies had *"an infinite amount of time"* to interpret public governance APs like the new European regulations (interviewee 9, start-up, 12-04-2024). When discussing how start-ups dealt with this, a metaphor that came up was "*ostriching, sticking your head in the sand"* (observations, start-up, 11-06-2024). Multinationals appeared to be somewhat better equipped for the work required, e.g., through the playbooks and workshops discussed prior.

Respondents mentioned that this difference in 'anticipatory agency' (Ahlqvist et al., 2012) between smaller and larger industry actors seemed to be influencing the MedTech landscape, with multinationals focusing more and more on regulatory expertise and closing down innovation departments, and start-ups finding it harder and harder to make it to market: "*Over the last 15 years, multinationals have increasingly focused on optimizing their existing products. Regulatory expertise has become much more important. You need a large organization to keep your products healthy on the market. […] These new regulations actually require all [industry actors] to think like a multinational and organize for risk management and quality control, whereas most startups are just 5 people in a room who know a little bit of everything."* (interviewee 12, scale-up/consulting, 03-05-2024). Nevertheless, when discussing APs aimed at grasping the anticipated future, participants who worked for multinationals also expressed complications, mainly related to a feeling of not having a *"seat at the table"* in MedTech governance discussions, meaning that many public governance activities remained a "*big black box"* (interviewee 14, 16-05-2024).

4.2 Undertaking the anticipated future

A second category of APs shared by industry actors seemed to be aimed at undertaking the anticipated future, to be able to move through the 'game rules' of governance, either by implementing them or by playing around them. As one MedTech industry actor noted: "*What this requires of us [industry actors] is not future proofing but future agility*" (observations, scale-up, 11-06-2024). For example, participants commonly discussed planning to move away from the European market until the impact of recent European regulations becomes more clear in the future. Larger companies (multinationals) sometimes debated withdrawing some of their products from European markets (i.e., not recertifying them under the new MDR) or launching in other areas of the world first. Smaller companies (start-ups and scale-ups) similarly discussed launching first in the United States (US), where the regulatory framework was considered more established, and expectations seemed more concrete, and therefore less uncertain. Another example of an undertaking AP was shared during one of the events observed. To deal with various new European regulations that limit the sharing of personal data, someone presented the option of 'homomorphic encryption' of data, which allowed companies to

work with converted data and still get relevant insights (observations, consulting, 11-06-2024). Finally, several interviewees from larger MedTech companies mentioned that they were reorganizing internally, to place a greater emphasis on regulatory expertise.

It seems that undertaking APs are aimed at implementing the expectations gathered during grasping APs (either by following these expectations or by circumventing them), require agility and creativity from industry actors, and are generally oriented towards reducing uncertainty in the short term. Importantly, undertaking the anticipated future involves actions that can have both intended and unintended effects from the perspective of public governance actors. For instance, the anticipated effect of the MDR was an increased focus on clinical evidence prior to market authorization. In response, smaller and medium-sized companies often implemented such changes by launching products first in other regions of the world while continuing to gather evidence. This behavior reflects both an implementation as well as a circumvention of the anticipated future. Similarly, when larger MedTech companies reorganize in anticipation of the HTAR and hire additional regulatory or HTA expertise, they are partly implementing the anticipated future. However, this expertise might also be used to explore options for circumvention. These examples illustrate how industry actors internalize the 'rules of the game' and make moves with their desired futures in mind. Sometimes this means implementation; other times, it means divergence. Whether their actions align with or deviate from the desired outcomes of governance actors depends on the context and the specific effects of their decisions.

These undertaking APs were complicated by several factors. First, participants discussed experiencing situations where they were stuck in APs with conflicting expectations from other actors in the MedTech governance landscape during APs. For example, start-ups were increasingly being asked by private funders (investors) to provide (early) HTA evidence, but they needed funding to be able to generate such evidence: *"We are in a catch-22 situation, we cannot treat many patients until we have statistically proven our value, but to prove our value we need to have treated a lot of patients.*" (interviewee 13, 13-05-2024). This resulted in a *"chicken and the egg story"* (interviewee 6, scale-up, 19-03-2024) that seemed difficult to break out of. Furthermore, participants explained how the 'rules of the game' seemed to play out inconsistently between different public governance actors, for example when following the MDR to gain EU market access: "*Once you start that MDR, you have to play the whole game and that is very expensive, because it is interpreted differently in different countries under the same European regulations. And that, of course, should never be the goal of European regulation." (Interviewee 7, start-up, 03-04-2024).* Similarly, at the national level participants explained that they encountered different expectations among stakeholders (including health

insurers, investors, professionals, and ZIN) in how they defined 'evidence', leading one participant to feel they were "*trying to prove ourselves in all sorts of directions and you often don't have the resources for that*" (interviewee 6, scale-up, 19-03-2024).

Second, these undertaking APs were complicated by a gut feeling that the governance framework was likely to change again in the near future. This meant that industry actors sometimes doubted whether they should put their efforts into implementing public governance activities, *"while we're not sure if it will be completely different again in 5 years."* (interviewee 14, multinational, 16-05-2024). Participants expressed a desire for *"stability, certainty, and clarity of the rules of the game"* (interviewee 5, multinational, 14-03-2024), as the current situation involved a lot of uncertainty. One participant argued that there will always be a degree of uncertainty in the governance of MedTech, but that this particular type of uncertainty should ideally be avoided: "*There is plannable uncertainty and there is unplannable uncertainty. If there is a very rigid process with high requirements, but you know what the process is like, then that plannable uncertainty is a better starting point than if you have to invest time and resources but have no idea what the process is or will be. In both cases, you have no control over the outcome, sometimes your innovation just doesn't make it, but the lack of a clear process is something that many [MedTech industry actors] find difficult." (interviewee 4, consulting, 21-02-2024)*

Third, participants mentioned that they had to balance between many different factors, likening this to *"playing chess at multiple boards"* (Interviewee 13, start-up, 13-05-2024). Undertaking the anticipated future seemed to be a careful balancing act: *"It is a balance between several factors, between clinical application, technological development, legislation and regulations, and marketing. We could create a product that has more clinical effect, but is technically more complicated, which would then require more in terms of regulations and compensation, making marketing more difficult."* (interviewee 6, scale-up, 19-03-2024). This weighing and balancing between different anticipations often led to industry actors choosing the least uncertain route, which was not necessarily also the most clinically relevant or technologically innovative one.

Similar to grasping APs, MedTech industry actors argued how these undertaking APs and their complications seemed to be influencing the MedTech industry landscape. As mentioned above, several MedTech industry actors were considering withdrawing their products from the European market and (initially) launching their products in other geographical areas. In addition to changing the product landscape, it seemed that uncertainties surrounding new regulations had created opportunities for new industry players. A whole industry of 'promissory organizations' (Pollock & Williams

(2010) was forming alongside MedTech companies, co-producing 'future knowledge': "*In the lowest MDR class you can certify MedTech yourself, so everyone tries to stay within that risk class, a lot of money is spent on lawyers to argue for this. […] And for the value plan, a whole advisory industry has emerged there too, all kinds of companies that will build your value profile for you." (interviewee 7, start-up, 03-04-2024).* Such consulting actors also offered more formal APs, such as scenario workshops, to help industry actors *"make decisions on what to do in-house and what to outsource in order to get to market quickly."* (interviewee 12, 03-05-2024).

4.3 Collaborating with public governance actors on the anticipated future

The APs of MedTech industry actors described above illustrate how the anticipations of industry and public governance actors interact with each other. For example, participants discussed how the goal of the Data Act was to make data more freely available but anticipated that the MedTech industry field may respond by making their products more expensive, creating a revenue model around data ('data commodification'), which they argued would then need be addressed by new regulations (observations, 11-06-2024). The discussion around 'homomorphic encryption' described above similarly highlights that APs by public governance actors create new actors and new practices, which will eventually require a response from public governance actors. Participants seemed to describe a kind of 'anticipatory loop' between the APs of public governance and private industry actors, as APs seem to compound when APs from one actor react to APs from the other, and so on. This loop seemed to be complicated by a difference in pace between public governance and private industry actors. On the one hand, industry actors seemed to innovate faster than public governance actors could regulate such innovation, as interviewee 14 argued: *"The pace of innovation is still going quite fast, while the pace of approval is lagging far behind"*(multinational, 16-05-2024). On the other hand, (especially smaller) industry actors seemed to 'lag behind' in terms of implementing public governance activities, as interviewee 7 argued*: "I don't think we are even at the AI Act yet. The field is still recovering from the MDR. And when I hear people talking about the HTAR, I mean, I think I'll be lucky if we even make it that far."* (start-up, 03-04-2024).

It seemed that both public governance and private industry actors were responding to the uncertainties related to such an 'anticipatory loop' by becoming (even) more proactive. Interviewee 4 described how public governance actors seemed to be *"more proactively looking at what is happening in the MedTech field, […] knowing what's coming and thinking along, so they can still influence things and won't reject it after 10 years of trying."* (consulting, 21-02-2024). Industry actors emphasized a similarly proactive attitude: *"As a company you need a very proactive regulatory strategy, then you can*

still influence things in Europe, as the interpretation of new regulations is still developing" (interviewee 15, scale-up, 21-06-2024*).* When discussing this proactive approach and related uncertainties, participants voiced a desire to engage in APs together with public governance actors. A typical example of an AP that aimed at collaborating was found in attending networking and information events. Participants explained that they often did this in anticipation of the new regulations, hoping to learn more about them in discussions with the public governance actors who were also present at such events. Another, more formal example of a collaborative AP was the creation of regulatory sandboxes, which industry actors noted helped to manage uncertainties together (observations, 14-03-2024). Such sandboxes were institutionalized in the AI ACT: *"Just this morning I looked at the latest texts of the AI Act, which has a section on regulatory sandboxes. That's a good example. You want to manage the risks of AI, but you also want innovation. In these sandboxes, you can play with governance, you are not stuck with the whole structure."* (interviewee 2, umbrella organization, 16-02-2024). Similarly, participants mentioned setting up pilot studies together with public governance actors. One respondent explained why such pilots are important: *"It is crucial that you can both step out of your role […] and start the conversation instead of just hiding behind a big wall. If you can bridge that and say, we can see in a pilot in a shorter period of time what this can or cannot do, then that will ultimately provide more certainty and clarity."* (interviewee 6, scale-up, 19-03-2024).

Participants also frequently mentioned examples from other countries. For example, participants noted how in the US industry actors can call the Food and Drug Administration (FDA; the US governance actor responsible for market access of MedTech) with questions, as the FDA website lists a phone number for an ombudsman, whereas in Europe this was not the case (observations, 14-03-2024). Participants also referred to 'early value dialogues' with NICE, the HTA agency for the UK, as a more formal AP where industry actors can request advice from governance actors before submission, "*so that you can talk to each other at an early stage and not afterwards, when the trials have already been done and we realize, oh, we forgot to do this."* (interviewee 8, multinational, 08-04-2024). Additionally, participants gave examples from the past, such as how NBs used to be able to give advice to industry during the certification process. Such advice giving by NBs has, however, been restricted under the MDR. Discussions about this change with several participants further highlighted the 'anticipatory loop' between industry and public governance actors, as the removal of advice giving by NBs under the MDR led to guessing work by MedTech companies, which apparently had increased an awareness of the importance of space for dialogue and experimentation in later governing practices, crystallizing for example into the sandboxes of the AI ACT.

These APs aimed at collaborating with public governance actors on the anticipated future were complicated by several factors. First, it seemed that collaborating on the anticipated future was complicated by who was invited and who was not invited to the AP, and different expectations from different actors. In addition to industry actors themselves often feeling like they did not have a *"seat at the table"* (interviewee 14, multinational, 16-05-2024), participants argued that patients should be more deliberately involved in APs, further arguing that *the* patient does not exist, but that multiple patient perspectives needed to be included (observations, 11-06-2024). Smaller actors (start-ups and sometimes scale-ups) also mentioned they had a difficult time getting a seat at the table. One of our participants argued that not many start-ups and scale-ups were able to attend networking and information events: *"It has to do with the trade-off that you have to make, especially as a start-up, that you can't do anything else if you go there, so it's just not feasible to go to a lot of these public events. And it has to do with the design of these events, a lot of plenary things are often organized, whereas the value for us is in the dialog."* (Interviewee 9, start-up, 12-04-2024). Participants also reflected on how large international actors were emerging in the MedTech field, such as Microsoft, Google, and Amazon, which they argued may be in a more powerful position than some public governance actors because of their size (observations, 11-06-2024). Such large industry actors could potentially use their size to influence the governance framework for their own benefit, taking a proverbial seat at the head of the table, potentially further blurring the already fluid boundaries between public and private governance actors.

Second, participants shared how these APs were complicated by an experienced path dependency from pharmaceutical governance, resulting in a more instrumental approach to MedTech governance and a more linear interpretation of MedTech development, by public governance actors. For example, an interviewee argued that studies requested by ZIN often seemed to be *"pharma-informed, with long double blind RCTs, which is difficult for MedTech innovations"* (interviewee 14, multinational, 16-05-2024). Again, this seemed particularly difficult for smaller companies: "*In pharma, there's a whole field of experts thinking about how to set up a clinical trial, what comparator to choose, how many patients to include. In the MedTech world, especially for the startups and scale-ups that have limited competencies, this is very difficult, because it is not that black and white."* (interviewee 4, consulting, 21-02-2024).

Third, collaborating in APs is complicated by trust between public and private governance actors. Participants shared that several, high-profile MedTech scandals over the past 15-25 years had exacerbated a bad reputation of MedTech industry actors. Examples mentioned included recalls of products that were deemed unsafe or MedTech

that was deemed uneconomical after widespread introduction. Participants expressed how this had created mistrust: *"Right now we're in foxholes, always defending ourselves"* (interviewee 2, consulting, 16-02-2024). Public governance actors seemed to be mainly rebuilding this trust at the macro level, within regulations and policy frameworks that appeared to construe trust as being auditable and transparent (observations, 11-06-2024), while participants expressed that it also required changes at micro and meso levels, developing space for discussion that allowed "*being more open to each other and aware of each other's challenges"* (interviewee 5, multinational, 14-03-2024). However, in the absence of trust and in fear of APs (such as lobbying) having a detrimental effect on (anticipatory) MedTech governance, such spaces seemed difficult to construct.

Like the first two categories of APs, participants argued that these APs aimed at grasping and undertaking the anticipated future together, had an impact on the governance framework of MedTech, at least in the Netherlands. One interviewee said that the Netherlands was known as a "*pilot-country"* but that *"situations often fail before implementation and scaling up*" (interviewee 14, multinational, 16-05-2024). This was difficult, because the experimental APs (such as pilot projects and sandboxes) created expectations among patients, customers and investors, while at the same time remaining "*quite vague, creating uncertainty and a kind of gray search"*(interviewee 6, scale-up, 19-03-2024). Participants mentioned that these APs should ideally include ways to transition from more experimental forms to more long-term approaches to governance. To do so, participants expressed that all actors involved in these APs should ideally collectively reflect on the learnings of these APs and translate them into broader policies, together.

Overall, it seemed that this required new competencies and frameworks. In terms of competencies, the development of trust and reflection seemed to be an important factor. Participants argued that creating trustworthy reflexive spaces required new competencies from public governance actors: "*I think you need connecting people. The competencies of [public governance actors] are now often extremely rich at the methodological level, but some of the solutions do not come from developing more complicated methods, but from connections." (interviewee 5, multinational, 14-03-2024).* In our observations on discussions about new frameworks, discussions often started with the importance of developing standard procedures, or 'blueprints' but ended up with 'the power of networking, knocking on the right door' (observations, 14-03-2024). When asked about this discrepancy, participants said that a checklist-like framework was often not possible because the governance of MedTech sometimes requires a "*tailor-made approach"* (interviewee 6, scale-up, 19-03-2024). Thus, APs aimed at grasping and undertaking together needed "*both a more general process and clear criteria, but also room for discussion"* (interviewee 4, consulting, 21-02-2024).

5. Conclusion and Discussion

This study contributes to our understanding of the role of APs within the broader politics and governance of and by anticipations, by showing the interdependent relationship between public and private governance actors in the MedTech field. We used an AP lens to critically reflect on how industry actors navigate and co-produce the (anticipatory) governance of MedTech. Our findings illustrate how industry actors engage in APs that aim to grasp and undertake the anticipated future, we summarize the factors that complicate these APs and describe ways in which these APs and their complications appear to be changing the MedTech landscape. Most importantly, we discussed how the APs of private industry and public governance actors seem to occur in a loop of interdependencies. While public governance actors aim to anticipate the work of industry actors (Michels et al., 2024), we find that industry actors aim to anticipate the work of public governance actors, creating a compounding of APs, as anticipation builds upon anticipation. We argue that this compounding, which we conceptualize as an 'anticipatory loop', seems to generate a desire to create reflexive space together, through collaborative and/or experimental APs that aim to grasp and undertake the anticipated future, together. At the same time, however, our data showed that such collaborative and/or experimental APs also have downsides, as they in turn generate broader anticipations that often fail to materialize into long-term governance practices and remain 'tentative'. Our findings are consistent with other scholars who have emphasized the importance of engagement and integration between different types of stakeholders in AG (Barben, 2008; Guston, 2014). Our findings add unique insights to this notion by demonstrating how, in the relative absence of such engagement and integration, stakeholder groups anticipate the anticipations of others, resulting in a compounding of anticipation that we conceptualize as an 'anticipatory loop'. We define this anticipatory loop as the dynamic relationship between APs of private and public actors, stemming from how those actors anticipate each other's expectations, particularly because they are interdependent in terms of technological and policy trajectories. The findings suggest that, within the context of MedTech governance, the anticipatory practice loop often operates as a spiral, with public and private actors continually adjusting their actions in response to one another over time. Furthermore, our findings suggest that the anticipatory loop may impact innovation. For instance, industry may elect to launch more simplified versions of their innovations, launch their products in other geographical areas instead, or withdraw products from market in anticipation of more stringent regulation. The loop may also have a potential impact on international equity, as less regulated areas where industry relocate may become unofficial "sandboxes" for experimentation with innovative products. The concept's broad definition, similar to that of APs, underscores its potential to influence a wide range of practices.

Its analytical application lies particularly in its ability to illuminate the dynamic relationships between practices of public and private governance actors and how these are co-constructing the present and future.

We have further shown how the uncertainties created and exacerbated in such an anticipatory loop have led not only to the already well-known pacing problem, conceptualized as a growing gap between the development of innovative (medical) technologies and their governance (Marchant et al., 2011; Wallach et al., 2018), but also to what we would call a 'reverse pacing problem', i.e., a growing gap between the implementation of governance policies and industry actors' keeping up with them. Our findings suggest that such a reverse pacing problem is most problematic for smaller industry actors (start-ups and scale-ups), who seem to have less anticipatory agency (Ahlqvist et al., 2012) available to understand and undertake the anticipated future.

On the notion of integration between different stakeholders, our findings also show that the boundaries between the different actors in AG of MedTech are becoming increasingly blurred, partly as a result of the APs discussed (see also Passchier, 2025). Larger MedTech companies reorganize to focus more on regulatory processes, for instance hiring former public officials, with some companies (including Microsoft, Google, and Amazon) in a potentially more powerful position than public governance actors because of their size. By drawing a boundary between private industry and public governance actors, we may have been engaging in performative construction ourselves. While this conceptual boundary allowed us to draw our conclusions, it likely overshadowed other parts. Future research could pay more attention to such blurring of boundaries in and by APs, for instance following specific APs in practice over time to further reflect on the boundaries and overlaps between the different actors involved in the AG of MedTech.

Such boundary blurring is related to the notion of trust. It appears that trust between private and public actors in the MedTech field has become precarious, at least in part due to several high-profile MedTech scandals in the recent past. It also seems that public governance actors are currently rebuilding this trust mainly at the macro level, through stricter regulation and proactive governance activities, while industry actors are advocating for creating more trust at the micro and meso level, getting out of "*foxholes*" (interviewee 2, 16-02-2024) and being more open to *"each other's challenges"* (interviewee 5, 14-03-2024). Our findings highlight the importance of trust and reputation in APs and show how a lack of trust increased uncertainty in AG. The complex relationship between trust and regulation has been extensively theorized in public administration (Oomsels & Bouckaert, 2014; Six & Verhoest, 2017) but seems underexplored

within the literature on AG through APs, where the uncertainties that are omnipresent in future expectations seem to complicate matters further. Trust is a multi-dimensional concept. Although a thorough analysis on different types of trust and their relation to APs and AG is outside of the scope of this article, avenues for future research emerging from our data are the relevance of institutional and epistemic trust for more formal APs (Bareis, 2024; Six & Verhoest, 2017), through regulations, procedures, and documentation, versus the relevance of interpersonal and affective trust for more informal or experimental APs, through openness, interorganizational trust and shared values (Oomsels & Bouckaert, 2014; Poppo et al., 2008). Further understanding of the ways in which different types of trust impact anticipatory approaches could help explain why certain anticipatory approaches succeed or struggle in practice.

Whereas the anticipatory practice loop may foster reflexivity *within* actor groups, we argue that the creation of reflexive space would foster *collaborative* reflexivity, offering a mechanism for better alignment of private innovation with public goals, mutual understanding and learning, prevention of regulatory silos, and potentially reducing the (reverse) pacing problem. Such reflexive space will likely never eliminate the anticipatory loop altogether but could hopefully eliminate some of the uncertainty that is inherent to its creation. Of course, such collaborative APs aimed at creating reflexive space pose challenges in terms of the risk of lobbying or other types of undue industry influence. To achieve reflexive space responsibly, they could be designed with safeguards in mind, such as diverse participation (including academics, civil society actors, and representatives from both larger and smaller firms), to reduce the risk of regulatory capture. Equally important is ensuring transparency and accountability, e.g., through the systematic documentation and public sharing of discussions and decisions. When structuring with such safeguards in mind, such reflexive spaces may even serve as counterweights to behind-the-scenes lobbying, encouraging public discussion and accountability instead, and in so doing reducing the risk of regulatory stagnation by fostering greater responsiveness through reflexivity. Although any governance mechanism carries risks, reflexive anticipatory spaces could offer a structured, proactive alternative to purely adversarial or siloed approaches, opening new possibilities for more inclusive and adaptive governance.

Furthermore, as we show, industry actors are not mere recipients of AG, but engage in various, mostly informal APs, that actively co-shape and sometimes undermine AG. Much of the literature on APs focuses on more formal and institutional approaches, whereas our explicit analytical focus on APs in the widest sense of the concept unearthed a number of more informal APs, such as making informal calls, developing playbooks, or hiring regulatory expertise. Interestingly, these more informal APs were

mostly shared during interviews, whereas our fieldnotes from the observed events reflected more formal APs. We urge future research to similarly shed light on more informal APs, as these more informal APs can influence the governance of MedTech just as more formal ones do (Muiderman et al., 2020), perhaps unearthing more informal APs of public actors as well.

Finally, we seek to deliberate on the theoretical relevance of the distinctions and parallels between the APs of industry actors that we have identified and the APs of public governance actors that are discussed in the academic literature. It appears that industry actors' APs are characterized by a more limited time horizon, a more circumscribed scope, and a heightened strategic nature. The following, aforementioned quote offers a concise yet illuminating encapsulation of such differences: "*What this requires of us [industry actors] is not future proofing but future agility*" (observations, scale-up, 11-06-2024). Private governance actors can strategically and agilely engage in APs that circumvent governance (e.g., by moving to other geographic areas), especially those larger MedTech companies that have invested in building their internal regulatory expertise and thus have an understanding of the (expected) changes in the governance framework. Governance actors are often more constrained to their constitutional demands to a certain geographic area (Passchier, 2025). There are also notable parallels in the APs of public and private governance actors, for example, both engage in collaborations to jointly anticipate the future and extend their reach (Michels et al., 2024; Visscher et al., 2021). Such supranational collaborations by public actors are an understandable move, especially in light of the agility of industry actors as discussed in this paper. However, they also complicate governance by public actors. The complicated political dimensions of cross-national collaborations by public actors in the area of MedTech governance, characterized by uncertainty, often make it difficult to reach decisions swiftly and respond promptly (Michels et al., 2024).

We posit that this discrepancy in anticipatory 'agility' further underscores the necessity to examine the APs of private governance actors, and their impact on the (anticipatory) governance of MedTech, with greater scrutiny. A relevant question for future research would be whether the complicating factors we identified—and the anticipatory loop more broadly—are influenced by differing temporal orientations in the anticipatory practices of public versus private governance actors. From our data, it seems plausible that public and private actors interpret and prioritize the short and long term in divergent ways (see alsoKeisler et al., 2021; Rycroft, 2006). In addition, we argue that it is important to pay more attention to the interdependencies between the different actors involved in APs, especially industry actors, as they are an important but under-discussed actor in the AG literature. Since we argue that anticipation builds

upon anticipation, it would be interesting to follow APs in practice over time (e.g., in a longitudinal study), to see in 'real-time' how actors respond to each other and how, if at all, the anticipatory loop plays out in practice. Sensitizing concepts for such research could include the notion of trust, boundary work, the degree of anticipatory agency of different actors, differing perceptions of time and time horizons, and the importance of space, both literal and metaphorical. Ideally, this would allow for refinement of the AG framework, to better understand the complexities of the governance of emerging (medical) technologies. Our findings also have practical relevance for the governance of MedTech. First, public governance actors should be aware of how these APs appear to be influencing the MedTech landscape. Participants mentioned how larger industry players were seemingly reorganizing to focus more and more on regulatory factors and closing innovation departments, and smaller players seemingly struggling to meet such regulatory demands. Whereas further research would be necessary to establish such claims, such findings are in line with other research on developments in the technology landscape and its relation to governance (e.g., Passchier, 2025). If so, these changes may have a potential detrimental impact on innovation, with some industry actors removing their products from the market or choosing to launch elsewhere. While some responses are ostensibly more in line with what public governance actors are trying to achieve, e.g., industry actors working to interpret regulations and implementing them by setting up trials, others may be less desirable e.g., industry actors moving to other geographical areas while they wait for the governance framework to crystallize further. We believe that it is important for governance actors to reflect on such potential future impact of their practices, and their desirability, with a potential role here for APs aimed at imaging diverse futures, such as simulations, visioning workshops, or back-casting pathways (Muiderman et al., 2020)

Public governance actors should also be aware of the complications identified with the APs. Interestingly, complications for all identified categories of APs identified seemed to revolve around three issues. First, complications arose around who was (not) invited to the AP and different expectations from different actors involved. This led to uncertainties about what was expected of MedTech industry actors and a sense that not everyone had a(n equal) seat at the table. Second, complications arose from different expectations over time. Regulations were described as moving goalposts, with participants describing a gut feeling expecting a governance overhaul in the (near) future, but also a path dependency on the past, with past pharmaceutical governance activities informing current MedTech governance activities. Finally, complications seemed to arise from a lack of trust, partly explained by an increasingly bad reputation due to semi recent scandals, leading to less openness and more invisibility of the work of industry actors. We believe that public governance actors should be aware of these three general issues,

and ideally should stimulate openness, trust and reflection between the different types of actors involved in the governance of MedTech.

Interestingly, on the one hand our findings underscore the potential of collaborative APs to stimulate such openness, trust, and reflection. "Undertaking" practices by private industry actors sometimes seem to emerge as responses to uncertainties identified during "grasping" APs, i.e., when private actors assess the anticipated future, they recognize areas of uncertainty or ambiguity in the regulatory landscape, which then inform their strategic moves. This offers potential for public governance actors. By recognizing that industry responses are often driven by uncertainties identified during the "grasping" phase, public governance actors can work to create anticipatory practices that work with such uncertainties, such as the events, sandboxes, pilots, or roundtables. Such collaborative APs between public and private actors could then provide for a reflexive space (Wiig et al., 2021), to share expectations and deliberate on uncertainties. A space for actors to practice (and perhaps fail at) anticipation without the regular pressure of accountability to, for instance, regulatory bodies.

Ideally, such efforts to engage in more proactive communication with industry stakeholders may then address potential regulatory ambiguities before they prompt disruptive "undertaking" behaviors. The events are a good example of such organized reflexive space, however, given the finding that smaller industry actors typically have less anticipatory agency available to attend such events, governing actors can think of diversified ways to organize reflexive space, especially as 95% of industry actors are smaller companies (MedTechEurope, 2022). In the absence of reflexive space, such smaller companies are less likely to survive, perhaps involuntarily fostering a market of larger MedTech actors, through the workings of the anticipatory loop. In more formal APs, reflexive space could be built into the "standard methodologies and processes". An interesting question would be if we should explore ways to create reflexive space in more informal APs, particularly for smaller industry actors, and, if so, how such space might be established in a way that supports societal needs?

On the other hand, we also want to emphasize the contested nature of such experimental, collaborative APs. As Ryghaug & Skjolsvold (2021) argue, experimental APs (like pilots and sandboxes) are important political sites for the production of future socio-technical orders. By providing a space in which political agency is somewhat removed, they can provide prospective legitimation (Harmon et al., 2023). In addition, they can generate expectations for patients and other stakeholders that fail to translate into long-term governance, meaning that these APs remain an "*intermediary space*" (Ryghaug & Skjølsvold, 2021, p. 56), and as such remain "*quite vague, creating uncer-*

tainty and a kind of gray search" (interviewee 6, 19-03-2024). Therefore, we posit that the governance of MedTech needs both experimental spaces for reflexive dialogue and experimental learning and more long-term, standardized procedures – the former providing potential ways to deal with "*unplannable uncertainty*" and the latter providing potential ways to deal with "*plannable uncertainty*" (interviewee 4, consulting, 21-02-2024).

We would like to end with a reflection on our limitations. Our findings should be interpreted keeping our specific empirical context in mind. Our data is situated mostly in the Dutch context and supplemented with insights from 1 industry actor from the German context. As such, our study provides only a partial insight into the APs of MedTech industry actors. Whereas MedTech industry actors operate within an international context, and (anticipatory) governance of MedTech is largely organized at a European level, each country has its own rules, regulations, and culture. As such, these APs may look different in other contexts, and further research on the APs of MedTech industry actors in other contexts would be useful to situate our findings. For example, our data suggests that the Dutch context is geared towards public-private partnerships and favors experimentation in the form of pilot projects, with one participant arguing the Netherlands is a 'pilot-country'. Other countries may have a different, perhaps more conservative attitude towards collaboration and experimentation.

In addition, while our study included a wide range of private MedTech industry actors, we did not include private investors. Our data show that investors are an interesting actor within the MedTech governance network, requesting and evaluating evidence, led by (as well as creating) expectations and uncertainties. While there exists research on the complicated role of investors in MedTech governance (Allers et al., 2024; Allers et al., 2023), it would be interesting to take a closer look at the position of private investors in the APs of MedTech industry actors, for example, in terms of how they shape anticipated futures and direct actions in the present.

Finally, we wish to critically reflect on how engagement with this research could be interpreted as an informal AP, akin to lobbying, wherein industry actors sought to influence governance by advocating for reflexive spaces or tailored approaches. We have aimed to give a critical reading of our respondents' APs, through the application of the AP lens and situating findings within the AG literature, aiming to demonstrate how public and private industry actors are deeply interdependent. Dismissing calls for reflexive space outright as a mere lobbying tactic, in our view, is not a constructive approach for MedTech governance, particularly given the significant uncertainties in this field. Nevertheless, our findings should always be interpreted with this in mind.

CHAPTER 5

Boundary Work In Efforts To Broaden HTA For MedTech Governance

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HTA between theory and practice: Exploring boundary work in broadening HTA for MedTech governance

Abstract

Objectives: In this paper, we explore the social and political practices involved in broadening health technology assessment (HTA) for medical technology (MedTech) governance. We take as our case study the Dutch HTA Methodology 2021-2024 Program, which aimed to broaden HTA methodologies to the assessment of MedTech, and in so doing, broadened the stakeholders involved. Our research question is as follows: How do stakeholders involved in the program interpret HTA (methodologies) for MedTech, and how do they envision multi-stakeholder collaboration on HTA (methodologies)?

Methods: We conducted 19 semi-structured interviews with program participants, including committee members and grant applicants. We also spent 120 hours observing program meetings as non-participants and conducted document analysis.

Results: Using boundary work as a sensitizing concept, we describe how broadening the actors involved both introduced and exposed different interpretations of HTA and HTA methodologies for MedTech. We describe three ways in which participants envisioned (potential) integration of these interpretations, which we term collaboration hybrids. Each collaboration hybrid encapsulates a way of navigating across boundaries.

Conclusions: Our findings highlight that attempts to broaden HTA into a more prominent aspect of MedTech governance challenge the boundaries of what is understood as proper HTA. We argue that reflecting explicitly on these different interpretations, and the diverse ways to integrate them, increases the relevance of the HTA methodologies developed and the collaborations initiated in the governance of MedTech through HTA.

Introduction

Health technology assessment (HTA) is becoming increasingly prominent in the governance of medical technologies (MedTech) (Hogarth et al., 2022; Hogarth, 2021). Within the polycentric regime of MedTech governance (Black, 2008), HTA is characterized as a multidisciplinary field that applies specific HTA methodologies to determine the value of health technologies to guide reimbursement decisions (O'Rourke et al., 2020). Commonly, HTA methodologies are based on scientifically generated evidence, use predominantly quantitative approaches, and focus on characteristics such as efficacy and cost, with cost-effectiveness modeling being a typical example (Leys, 2003). Most HTA research is conducted between international market access and national reimbursement (Enzing et al., 2021). Finally, the majority of HTA research has focused on pharmaceuticals, where regulatory requirements are said to be more conducive to this type of assessment (Enzing et al., 2021).

However, in continuing effort to guide healthcare decision-making, there is ongoing debate about broadening HTA (methodologies) (Enzing, 2023; Jiu et al., 2022). For instance, scholars discuss the application of HTA methodologies beyond pharmaceuticals to study the value of MedTech, often noting a paucity of evidence and complicating contextual factors as complicating factors (Bloemen & Oortwijn, 2024; Enzing et al., 2021; Tarricone et al., 2017). Scholars also discuss expanding the timeframe to earlier (early HTA, (Grutters et al., 2022) and later assessment of technologies (real-world evidence, (Klein et al., 2022). Such broadening involves new stakeholders, leading, e.g., to more engagement between regulators and HTA agencies (Bloem et al., 2021; Hogervorst et al., 2023). Other stakeholders who are increasingly being engaged include patients (Gunn et al., 2021) and social science researchers examining factors that are more difficult to quantify (Abrishami et al., 2017). In theory, such multi-stakeholder collaboration could contribute to a more comprehensive assessment (Abrishami, 2018; Gunn, 2023; Guston, 2014). However, little is known about the social and political work that such broadening entails in practice.

In this paper, we aim to examine the social and political practices of efforts to broaden HTA in practice, in the context of MedTech research funding. The Dutch Ministry of Health, Welfare, and Sport (VWS) established a grant program to fund the development of HTA methodologies (ZonMw, 2021). The grant program was administered by ZonMw, the Dutch government's main health research funding agency. Funding agencies play an interesting role in governing innovation, sitting at the intersection of policy agendas and scientific communities (Smith et al., 2024). The ZonMw HTA Methodology 2021-2024 Program (hereafter: the program) involved stakeholders from diverse backgrounds

(policy, science, and practice) to design the calls for proposals and evaluate funding eligibility. Our research question is: How do stakeholders involved in the program interpret HTA (methodologies) for MedTech, and how do they envision multi-stakeholder collaboration on HTA (methodologies)? We show how participants of the program held different interpretations of the term 'HTA methodologies', elaborate on these different interpretations and on ways the respondents believed these should be integrated.

Boundary work in HTA

The aim to broaden HTA is both a result of its general maturation and a response to novel technologies, societal pressures, and regulatory changes (Enzing, 2023; Schuller & Söderholm Werkö, 2017). The broadening of HTA is embodied in the HTA core-model (EUnetHTA, 2021) and the recently updated formal definition of HTA, emphasizing its multidisciplinary nature and adding "ethical, social, cultural, and legal issues, organizational and environmental aspects, and broader implications for patients, relatives, caregivers, and the general population" (O'Rourke et al., 2020) (p. 188). We argue that broadening the landscape of (f)actors in HTA can challenge the boundaries of what is understood as HTA. When the boundaries of scientific concepts are expanded and new actors enter, boundary work often occurs (Gieryn, 1983). Gieryn defined boundary work as efforts to create, defend, and attack boundaries. Others later showed how actors can engage in boundary work to create hybrids around boundaries (Bijker et al., 2009) (p. 147-149). This research emphasizes that boundary work is not, as the name might suggest, a strictly exclusionary practice, but rather a constructive process necessary to achieve multi-stakeholder collaboration.

Several studies have already examined boundary work in HTA, mostly around patient or public involvement (Bray, 2018; Gauvin et al., 2010). This research shows that such involvement, although often difficult to implement due to epistemic hierarchies and organizational complexities, could add important dimensions to HTA. However, boundary work that occurs when stakeholders are explicitly invited to participate in the development of HTA *methodologies* has not been studied previously. As the primary tools of HTA, such methodologies embody several guiding forces, e.g., the perspectives embedded, the factors included, and the intended timeframe. Therefore, we use boundary work as a sensitizing concept to analyze the practices that arise when both the landscape of actors in and the types of technologies evaluated by HTA methodologies are expanded.

To do so, we follow Lindberg et al.'s (Lindberg et al., 2017) categories of boundary work, namely boundary closure, spanning, and blurring (/breaching). Boundary closure involves further demarcating boundaries, often to protect autonomy. Boundary spanning

involves establishing common ground between groups, while maintaining separate identities. Boundary blurring challenges existing boundaries and can generate knowledge that can be used where stakeholders from different worlds come together. We use these categories to describe three 'collaboration hybrids' (Bijker et al., 2009) (p. 147-149), i.e., ways to integrate the different perspectives. As our analysis will show, collaboration is possible in all three hybrids, but each category has a different function in setting the rules for integration across worlds.

The ZonMw HTA Methodology 2021-2024 Program

ZonMw facilitated the program, in collaboration with the Dutch National Health Care Institute (ZIN). ZIN is the Dutch HTA agency and therefore a major user of HTA methodology. The program started with a gap analysis of the need for HTA methodologies among relevant stakeholders (UMC, 2021). The gap report advocated bringing together stakeholders from policy, practice, and research, "so that all aspects can be examined from a common vision and implemented in the short term" (UMC, 2021) (p. 18). ZonMw established separate program and evaluation committees for the program. The program committee was responsible for defining a theme for each of the three funding rounds and included people from different backgrounds. The evaluation committee was responsible for evaluating the grant applications. In the first round, it consisted mainly of people from policy and science, working in the field of HTA; in the second and third rounds, more participants from practice were added. ZonMw hoped that by broadening the committees, a wider range of factors would be considered. The theme of the first round was "Methodology for valuation of incrementally developing MedTech". The themes for the second and third rounds were not specifically about MedTech. The program thus embodied both a broadening the stakeholders involved and of the technologies assessed through HTA (methodologies), providing an interesting case-study to study how their interplay led to boundary work, around the interpretation of HTA (methodologies) and between the different stakeholders involved.

Data collection and analysis

Our study applied a qualitative, multi-method, in-depth study design, triangulating data from document analysis, observations, and in-depth interviews. We analyzed documents related to the program (Supplementary Materials). In addition, we observed participants of both committees during relevant meetings between February and November 2023, including recordings of previous meetings from Round 1 (120 hours, with 10 hours of recordings). Since we were interested in broadening HTA (methodologies) for MedTech, our analysis primarily concerned the first round, supplemented by general observations from the second and third funding rounds. Initially, we deliberately left the focus of our observations open. As our analysis developed, we focused on discus-

sions about what was (not) considered HTA (methodology) for MedTech; how participants engaged with each other; and which projects were (not) funded.

Besides observations and document analysis, we conducted 19 semi-structured interviews with members of both committees and applicants. The interviewees fell into three categories: policy, practice, and science (Table 1). Participants from a policy background included VWS, ZonMw and ZIN employees. Participants from practice included a healthcare professional, a hospital administrator, an industry representative, and a patient advocate. From a science background, several HTA experts from mostly Dutch institutions participated. As boundaries between these fields can be somewhat fluid (Wehrens, 2014) and stakeholders often play multiple roles (Jiu et al., 2022), some participants could be placed in multiple categories.

All interviews were conducted between April and September 2023, lasted approximately one hour, and involved one interviewer and one interviewee. Two interviews were conducted in English and the rest in Dutch. One interview was held face-to-face and the rest online using Microsoft Teams. The interviewer used an interview guide (Supplementary Materials), asking participants to elaborate on their affinity for HTA and MedTech, experiences with the program, and ideas regarding collaborating on HTA methodologies for MedTech. Interviews were recorded using Microsoft Teams and transcribed verbatim.

Transcripts, documents, and field notes were analyzed thematically, coded by the first author, and reviewed by the other authors. We followed an abductive approach to build iteratively on our emerging data and existing theories (Tavory, 2014), homing in on boundary work (coding list in Supplementary Materials). The analysis was further refined in recurring discussions among the authors and other scholars. We member-checked the preliminary results with participants on November 7, 2023, during which participants further reflected on the objectivity of HTA methodologies, the gradient nature of the different interpretations of HTA (methodologies) identified, and the relationship between the different interpretations and the collaboration hybrids.

Our study was conducted as part of an academic collaboration with, and partially funded by, ZIN. Researcher independence is guaranteed in the written partnership agreement between ZIN and our research faculty. Further distance was created by using a conceptual framework in which to situate the research findings and by recurring discussions between the authors (two of whom did not attend committee meetings) and their broader research network. The study received ethical approval from the Erasmus School of Health Policy and Management (ETH2223-0189). All participants provided

written informed consent. Full access to relevant documents and committee meetings was granted through a temporary agreement with ZonMw.

Results

In observing the committee meetings, we found that discussions centered on the applicability of HTA methodologies to MedTech, the level of decision-making HTA methodologies should involve, and whether grant applicants actually proposed HTA methodologies. Because the approval of grant applications provided a tangible example of the boundary work around HTA (methodologies), we categorized the five approved Round 1 projects in Table 2. We list *approved* projects because these are publicly available (ZonMw, ND), whereas rejected projects are not. As the table shows, most approved projects from round 1 coded HTA methodologies for MedTech differently from HTA methodologies for pharmaceuticals, for various reasons. Furthermore, there was variety in the decision-making context aimed for. Lastly, HTA methodologies were interpreted in different ways, namely as "methods to arrive at and evaluate evidence," "processes to come to a weighted judgment," or "ideas to tackle broad societal issues." Overall, these discussions pointed to different interpretations of HTA. In the following section, we describe the discussions around each of the categories of table 2 in more detail, using insights from our interviews as well as observations and document analysis relating to all grant applications from round 1.

1. Different interpretations of HTA and HTA methodologies

HTA methodologies different for MedTech?

Some participants advocated for moving away from a 'pharmaceutical framing' in HTA, arguing that the practical context in which MedTech innovations are implemented is more influential. To understand this influence, stakeholders from practice needed to be more deliberately involved in the HTA methodology process. Otherwise, "the world of practice and the world of HTA will drift further and further apart" (Participant 13). Participants also discussed how HTA methodologies for MedTech should somehow lead to faster decisions, as they tend to develop incrementally. To address this, participants argued that "it would be great to have measures for non-RCTs and more dynamic approaches, as one-off measures do not always work for MedTech" (Observations, 10-03-2022).

Other participants, however, argued that MedTech is no different from pharmaceuticals. "The evidence around pharmaceuticals can also develop incrementally. It is quite similar, you have an innovation and you want to know: what does it do, what are the

costs and effects?" (Participant 3). Therefore, HTA methodologies should be largely the same for MedTech, otherwise incomparable quantities and unfair systems would ensue. These participants did describe specific differences, such as learning curves for MedTech users, they labeled these as methodological improvements that could be addressed within the current boundaries of HTA.

Different HTA methodologies for different decision-making contexts?

Within the program, it seemed that different values were at play at different levels of decision-making. Several participants argued that MedTech governance required HTA methodologies that can be applied at local levels, e.g., for the implementation of a technology within a specific hospital. However, several of such grant applications were rejected because of limited relevance outside of the study context.

At the national level, participants struggled with applying existing HTA methodologies to the large number of MedTech products. Although some seemed to believe that it would be good to extend national jurisdictional control to more routine assessment of MedTech, and apply similar rules to all technologies to ensure fairness, they struggled with the amount of work this would entail: "If every time a new bell or whistle is added [to MedTech] or an update to an app is released, you have to assess it in the same way, that will simply not work" (Participant 2). This meant that at the national level, participants wanted to develop "dynamic" HTA methodologies because "MedTech is a moving target" (Observations, 12-4-2023).

Lastly, participants argued that while it may be valuable to discuss HTA methodologies that worked specifically in local or national contexts, HTA is an international field. "Ultimately HTA develops internationally. It is relevant that these local issues come up, but we need to think carefully [within the program] whether these are also internationally relevant issues if we want to contribute to advancing HTA beyond our borders." (Participant 14). At the international level, e.g., there was a need for HTA methodologies for cross-country collaboration in the context of the new HTA regulation (EU, 2021b).

Is this really HTA methodology?

During the evaluation committee meetings, participants often asked: "Is this really HTA methodology?" We identified three different interpretations of an "HTA methodology". The first interpretation focused on *methods*, namely:

> *"The set of methods you need to arrive at and evaluate evidence about a new medical technology, in a broad sense, from medicine to a mental health intervention, in terms of effectiveness, cost-effectiveness, and possibly also necessity,*

i.e., how to properly value costs and effects, how to properly map them , how to measure them against each other, how to determine necessity, and how to discount." (Participant 17)

The second interpretation of HTA methodology viewed it as:

"Processes to come to a weighted judgment about a technology, bringing all aspects to light, incorporating interactivity as a necessary element to explore how different aspects are important to different actors. Because every choice for a methodology, also has a values implication and that often remains implicit now." (Participant 10)

Here, the question to be addressed by the program was "how to manage the friction between differing perspectives in decision-making, e.g., how to make choices between different perspectives, which perspectives to honor or perhaps prioritize" (Observations, 12-4-2023).

The third interpretation understood HTA methodology most broadly, as:

"Ideas that answer important questions that are currently left unanswered [within HTA], that introduce more diverse perspectives. We have to find out-of-the-box ideas, because healthcare needs to transform." (Observations, 06-06-2023)

Here, participants explicitly referred to practical issues that are difficult to address within the boundaries of conventional HTA, e.g., in prevention or non-curative care, as well as to broader societal issues such as sustainability. This interpretation often led to discussions about the generalizability of proposed HTA methodologies to other technologies and contexts, with most proposals fitting this category rejected for limited generalizability.

Conventional, participatory, or exploratory HTA

"This new definition of HTA [see O'Rourke et al. 2020], it is very broad and in principle includes everything. But I notice that in practice, HTA is still viewed very traditionally. I think that's the problem. We can define it differently and theoretically see that it's different from traditional HTA, but in practice..." (Observations, 07-11-2023)

Overall, the discussions pointed to different interpretations of HTA, in practice. At one end of the spectrum was a conventional interpretation, based on a systematic approach that applies consistently to all health technologies (including pharmaceuticals and MedTech), develops internationally, and is concerned with methods for generating and evaluating evidence. Another interpretation portrayed a more participatory HTA, aimed at managing the friction between different perspectives and seemingly more concerned with differences between technologies. At the other end of the spectrum was an exploratory HTA, which seemed to challenge conventional boundaries in order to address broader societal challenges, using ideas that were often not always generalizable to other technologies.

2. Collaboration hybrids: Integrating perspectives

Amid the different interpretations of HTA (methodologies), most participants argued in favor of finding a middle ground. However, participants held different ideas about what such a middle ground should look like. Below we describe three different ways of integrating perspectives (Table 3), into a collaboration hybrid (Bijker et al., 2009) (p.147-149), based on discussions with participants about what multi-stakeholder collaboration around HTA methodologies for MedTech *should* look like.

Collaboration hybrid 1: Boundary closure

Several participants advocated upholding the boundaries between science, policy, and practice in collaborations on HTA methodologies for MedTech, with scientific HTA experts taking the lead: "Then you need the outside world to raise relevant issues and to draw attention to them. But it is up to the HTA experts to develop their own toolbox" (Participant 17). It was considered important to have stakeholders from practice and policy to provide insight into what was needed and to receive the results, but not for these stakeholders to be involved in HTA *methodology* development, as this might influence outcomes:

> *"To each their job. The essence of HTA is often being the bearer of bad news. Then you can work together, but that is never nice to hear. And if it becomes a race to deliver good news... then HTA risks becoming more of a marketing instrument." (Participant 3)*

This hybrid defines HTA methodologies mainly according to the first interpretation, i.e., as *methods* for evaluating evidence, corresponding to conventional HTA. Participants questioned the usefulness of including a wider range of stakeholders: "To understand

this, you have to already understand it" (Observations, 09-06-2023). The main drawback participants mentioned to this approach was that too much separation between the worlds could result in HTA methodologies that are not useful to policy or practice:

> *"For example, the VOI analysis, used to see how valuable it is to generate additional evidence. Methodologically it is interesting, but someone who is more distant [from HTA] might wonder if it is really important, sometimes you see a mismatch in the level of detail sought after." (Participant 7)*

Collaboration hybrid 2: Boundary spanning

Other participants similarly wanted to maintain the boundaries between the different worlds in the development of HTA methodologies for MedTech, but more deliberately aimed to build bridges between them. Participants advocated for more discussion between stakeholders during HTA methodology development. In such discussions, each stakeholder would play their own role and the boundaries between worlds were clearly described, e.g., "science ultimately needs academic papers, practice to improve healthcare and policy to reduce uncertainty" (Participant 12). Clearly marking these boundaries helped determine where to build the metaphorical bridge.

This hybrid defines HTA methodologies mainly according to the second interpretation, i.e., as processes to come to a weighted judgment, corresponding to participatory HTA. An important boundary spanning practice was formulating a common ground, for example, the rising healthcare costs and how this would affect each stakeholder (Observations, 24-03-2023). Another form of boundary spanning involved speaking the same language:

> *"One thing I used to do a lot is just call patient organizations. Explain what the [HTA] procedure is, the terminology, the jargon. I never lost my independence, but you just get a lot further that way." (Participant 12)*

Some participants worried that the need to speak the same language meant that some perspectives would still be lost within HTA methodology development. Because the HTA process is complex, input from some stakeholders, e.g., informal caregivers, remained limited in practice (Observations, 07-11-2023).

Collaboration hybrid 3: Boundary blurring

A third way of integrating perspectives concerns a more explicit blurring of the boundaries between stakeholders in developing HTA methodologies for MedTech. Some participants argued that the specific pressures of MedTech call for a new paradigm:

> *"Maybe we need to come up with something entirely new for MedTech. I wonder, because we don't seem to be getting anywhere in these discussions, and with the problems we face, we don't have much more time." (Observations, 07-11-2023)*

Participants argued that HTA should adapt and "not represent historical interests" (Observations, 07-11-2023). This hybrid saw HTA methodologies mainly according to the third interpretation, i.e., as ideas to tackle societal issues, corresponding to exploratory HTA. Participants wanted to generate knowledge of more practical use, giving participants from practice a more deliberate role in developing HTA methodologies. However, some stakeholders were concerned that such a paradigm shift would negate the objectivity of HTA methodologies. "This could give stakeholders an opportunity to increase the focus on certain factors, and push decisions towards reimbursement" (Observations, 07-11-2023). During our data collection period, no consensus was reached on the preferred way to integrate the different perspectives on HTA (methodologies) for MedTech.

Discussion

Our study shows that attempts to broaden HTA methodologies towards MedTech governance, by expanding the technologies under assessment and involving more actors, in practice lead to boundary work, around the interpretation of HTA (methodologies) and between the different stakeholders involved. In general, our findings point to a friction between a theoretical push towards HTA broadening and the more practical, day-to-day aspects of *doing* HTA broadening. With regard to the Netherlands, for example, plans to extend HTA to MedTech governance are outlined in various policy documents. A letter from VWS (VWS, 2022) highlights HTA's potential to provide more insight into MedTech effectiveness. Although the theoretical definition of HTA (O'Rourke et al., 2020) would imply that HTA is appropriate for such applications, our findings show that the broadening of HTA is still under discussion and "in practice HTA is still viewed very traditionally" (Observations, 07-11-2023). As the traditional or conventional approach interprets HTA methodologies as "methods to arrive at and evaluate evidence", we expect this approach to be particularly difficult in areas where "neutral or unbiased" evidence (Bloemen et al., 2024) may be considered scarce, as is often the case in MedTech governance (Andersson et al., 2021).

The program's focus on broader stakeholder involvement in the development of HTA methodologies for MedTech led to discussions about what constitutes proper HTA and what is (not) considered a relevant HTA methodology. Our findings are in line with Bloemen & Oortwijn (Bloemen & Oortwijn, 2024), who show that implicit assumptions, such

as a commitment to the principles of evidence-based medicine, complicate the adoption of new methodologies (for MedTech) and require a discussion about "the role of HTA, stakeholder involvement and appropriate evidence" (p.2). Importantly, stakeholder engagement through deliberative processes is certainly not new to HTA (Bond et al., 2020). However, articles often make over-generalizations, such as that such involvement inherently ensures that "a wide range of values and their relative importance are understood" (Monleon et al., 2023) (p. 4). We show how such common understanding for sure is not a given. In addition, when discussed in more detail, stakeholder involvement is often positioned outside of the assessment phase, for example, during scoping, prioritization, or appraisal (e.g., Baltussen et al., 2017; Oortwijn et al., 2020). Our case study hence shows that, first, stakeholder engagement does not automatically lead to the inclusion of a broad range of values, but is much more complex in practice and requires reflection on how to integrate perspectives, and, second, stakeholder engagement is also warranted inside of the assessment phase, as stakeholder engagement within the development of the methodologies used for assessment exposed assumptions embedded in such methods that might otherwise remain implicit, e.g., about relevant decision-making contexts, about ideas regarding evidence, and about whose perspective counts.

The above corresponds to a broader recognition within the HTA literature that HTA inherently requires making normative value judgments, that different stakeholders likely define a problem in different ways, and that decisions are already made on whose judgment are taken into account (Refolo et al., 2023; van der Wilt et al., 2022). Explicit, a-priori reflection on the boundary work inherent to multi-stakeholder integration in HTA is therefore warranted, as attention needs to be paid to the ways in which voices are integrated (Hajer & Versteeg, 2005). The collaboration hybrids we have identified could serve as a starting point, going beyond mere recognition of stakeholder roles in HTA methodology development in existing frameworks (e.g., (Jiu et al., 2022), to explicit reflection on *how* to integrate the perspectives of these different roles. Without such consideration, collaborations around broadening HTA for MedTech run the risk of leaving most if not all stakeholders involved potentially dissatisfied, ultimately missing the goal of more comprehensive assessment. This is in line with the work of Bray (Bray, 2018), who highlighted that both HTA experts and patients were dissatisfied with attempts to integrate patient perspectives into the Canadian HTA program (p. 255). In her case, Bray argues that the way in which patient input was facilitated may have created barriers to meaningful integration of perspectives (p. 258). Similarly, the limited level of explicit reflection in our case study on the way perspectives should be integrated can be seen as 'taking care of' instead of 'caring for' stakeholder engagement and integration in HTA (Viseu, 2015).

Our findings are relevant for policymakers. First, we urge stakeholders involved in (funding for) the development of HTA methodologies for MedTech, to be aware of the different interpretations of HTA (methodologies). In particular, we urge reflection on the difference between "method" and "methodology". Although often used interchangeably, there is an important distinction. Methods are the "techniques for gathering evidence" (Carter & Little, 2007) (p. 1317). Methodologies, on the other hand, are "the assumptions, principles, and procedures in a particular approach to inquiry" (Carter & Little, 2007) (p. 1317). By broadening to other stakeholders and technologies, the program challenged the very assumptions behind the techniques of HTA methods, as different participants held different assumptions, and the extension to MedTech exposed assumptions that may have remained implicit when applied to a more homogeneous set of technologies. To illustrate this point with an example, HTA practitioners often encounter a lack of evidence from RCTs (the gold standard of evidence in HTA) when applying conventional HTA *methods* to MedTech (Enzing et al., 2021; Tarricone et al., 2017). From a *method* perspective, one might argue improving the RCT technique for MedTech, or alternatively, developing techniques to adapt RCTs to the characteristics of MedTech. From a *methodological* perspective, one might question the assumptions behind RCTs as the gold standard and ask questions about the process, e.g., should HTA practitioners broaden their understanding of evidence, and where does this conflict with technical rules embedded (implicitly and explicitly) in existing methods? We believe that this distinction is relevant in light of the ongoing broadening of HTA and is likely to extend beyond MedTech to the assessment of other novel or complex technologies with high uncertainty (Angelillo et al., 2023; Hogervorst et al., 2023).

Second, we believe that policymakers should stimulate a discussion about the collaboration hybrids and in so doing stimulate a "supportive environment" (Bloemen & Oortwijn, 2024) (p.9), that allows for reflection on the normative assumptions behind HTA, which, as we show, become explicit when experimenting with HTA broadening in practice. Several authors have already discussed the need for a facilitator (or 'boundary organization') to guide multi-stakeholder integration in HTA (Gauvin et al., 2010; Husereau et al., 2016). Although an in-depth exploration of the suitability of organizations such as ZonMw (or ZIN, for that matter) is beyond the scope of this article, we believe it constitutes direction for future research. If HTA continues to expand, leading to boundary work by all actors involved, should there be an assigned convenor, and who is equipped for this role (in the Netherlands as well as abroad)?

Finally, we would like to reflect on the strengths and limitations of our study. Our main strength is the triangulation of data sources: the review of the literature and relevant documents, our interviews with diverse participants, and our observations during rel-

evant meetings. This approach allowed for a detailed analysis of the different ways in which participants envisioned multi-stakeholder collaboration on HTA methodologies for MedTech. However, it would have been interesting to analyze the multi-stakeholder engagement that occurred *within* the approved grant projects. This would have provided additional insight into how different perspectives are (not) integrated in practice, and perhaps more explicitly demonstrated the impact on the comprehensiveness of assessment. Unfortunately, this was not possible during the time of data collection. In addition, our findings should be interpreted within the specific empirical context of our case study. While HTA is an international field, the context of our study is the Netherlands. As such, it provides only partial insight into multi-stakeholder engagement in the broadening of HTA (methodologies) for MedTech. In other contexts, engagement may potentially lead to different interpretations and different options for integration. Further research on the social and political practices of HTA broadening in different contexts would therefore be useful to situate our findings.

Conclusion

Our case study was uniquely positioned to examine what happens in practice when trying to involve multiple stakeholders in the development of HTA methodologies for MedTech. We highlighted different interpretations and showed how multi-stakeholder integration was conceptualized in different ways. In what we have termed "conventional HTA", HTA methodologies are interpreted as "methods to arrive at and evaluate evidence". Here, multi-stakeholder engagement is placed more outside the HTA methodology development process, resulting in boundary closure practices. We also identified a "participatory HTA", in which HTA methodologies are interpreted as "processes to come to a weighted judgment". Multi-stakeholder engagement is then situated around the boundaries of HTA methodology development, resulting in boundary spanning practices. Finally, "exploratory HTA" interprets HTA methodologies as "ideas to tackle broad societal issues" and places multi-stakeholder engagement at the center of HTA methodology development. Overall, our findings highlight that broadening HTA into a more prominent aspect of MedTech governance challenges the boundaries of what is understood as proper HTA, with different options for integrating interpretations. We believe that it is important for those involved in the study and practice of MedTech governance to be aware of and reflect on these different ways.

Discussion

In this dissertation, I have explored policy practices and discourses of 'futureproofing' MedTech governance, in particular in the day-to-day context of HTA and HTA agencies. My studies highlight how uncertainties about the future, and ways to act in the present, impact both public governance actors, who grapple with which MedTech innovations to anticipate and how, as well as private governance actors (MedTech companies), who grapple with anticipating how they will be governed. What complicates matters more is a growing sense of urgency to address those uncertainties, today (e.g., Geisemann & Geiger, 2024; Visser, 2024): The future is now (Zorginstituut, 2020b).

To this end, MedTech governance actors increasingly collaborate in anticipatory practices, seemingly in an effort to 'know more, sooner, together', as I explained in the introduction. Guided by an emerging theoretical framework centered on anticipatory governance and boundary work, I set out to explore how this desire to 'know more, sooner, together' plays out in the policy practices and discourses of MedTech governance, and to what consequence. Through an academic collaboration with ZIN, the Dutch HTA agency, I was given a rather unique level of ethnographic entry into the day-to-day levels of governance of innovative MedTech, in the Dutch and larger European context. The main research question explored in this dissertation is:

How are anticipatory practices shaped by and shaping the governance of MedTech?

The findings are structured around two primary research aims. The first aim was to investigate how applying an anticipatory governance lens to the practices of MedTech actors could inform and enrich existing literature on MedTech governance and HTA. The second aim was to examine how empirical case studies of anticipatory practices in the MedTech governance and HTA context could, in turn, contribute to literature on anticipatory governance. In this chapter, I will discuss my findings. First, I elaborate on the findings for research aims 1 and 2. Then, I combine my findings to answer the main research question and formulate recommendations for future research. Next, I present policy recommendations for ZIN and other HTA agencies, followed by methodological reflections. Finally, I end this discussion section by drawing a conclusion and sharing final remarks.

Research aim 1: Exploring MedTech Governance and HTA through an Anticipatory Governance Lens

This dissertation shows that adopting an interpretive-constructivist perspective in general, and the conceptual lens of anticipatory governance in particular, contributes to our understanding of MedTech governance and HTA. My predominantly practice-based

approach provides a complement to more commonly applied, positivistic approaches in this area of research (e.g., Fuchs et al., 2017; Olberg et al., 2017; Tarricone et al., 2020; Tarricone et al., 2017). In particular, it allowed me to delve into the 'politics of anticipation' in MedTech governance and HTA, in terms of more or less dominant framings of the future, different ways of engaging with uncertainties, and how multiple objectives and expectations coexist and conflict. Furthermore, the findings underline how such factors appear to influence the MedTech landscape, as perceived by participants. Consequently, this study makes a contribution to existing literature on MedTech governance and the broadening of HTA. Below I will elaborate on this contribution.

Dominant framings of the future

At the day-to-day level, previous experiences of MedTech governance actors guide anticipation and ways of framing the present, creating dominant ways of seeing the future that make it difficult to imagine anticipatory governance of MedTech 'otherwise'. In Chapter 3, I describe how one micro-regime of anticipation seemed most dominant, namely, the expectation that the MedTech horizon scanning tool could be used to gather appropriate evidence for HTA. Here, participants frequently referred to experiences with horizon scanning in the context of pharmaceutical governance. This led to specific expectations that had real consequences for how MedTech governance was imagined and 'done' in the present. For example, the MedTech horizon scanning tool was conceived in a rather linear way and the time horizon considered was relatively short, close to the expected future reimbursement of the MedTech innovations, as at that point the most relevant appropriate evidence for MedTech was expected to be available. In defining evidence, participants also often referred to previous experience with pharmaceuticals, mentioning that things were much better organized in that context, and anticipating that MedTech would follow suit.

In Chapter 3, I have referred to this framing as 'pharmaceutical framing' (Michels et al., 2024). Upon further reflection, I would like to add more nuance. The framing seems to rest on 'conventional' HTA, that indeed has been developed mostly in relation to pharmaceuticals (Leys, 2003). As defined by one of the participants in Chapter 5, conventional HTA is "the set of methods you need to arrive at and evaluate evidence about a new medical technology, in a broad sense, from medicine to a mental health intervention, in terms of effectiveness, cost-effectiveness, and possibly also necessity, i.e., how to properly value costs and effects, how to properly map them, how to measure them against each other, how to determine necessity, and how to discount."

The literature on evidence for valuing MedTech paints a worrisome picture for such an interpretation of HTA in the context of MedTech governance. Whilst for some Med-

Tech innovations this approach allows for a meaningful reduction of uncertainty (e.g., Zorginstituut, 2018; Zorginstituut, 2020c), for many, it proves insufficient: Literature on such cases highlight that information on MedTech is often not routinely collected and published, and that over time such evidence often contains conflicting, sometimes even polarized arguments about the (added) value of emerging MedTech (e.g., Abrishami et al., 2020; Rothery et al., 2017; Tarricone et al., 2017). Still, many of the public governance actors' anticipations seemed geared towards a future where appropriate evidence *would* be available and conclusive for MedTech. For example, participants referenced how new EU regulations would increase the focus on appropriate evidence in market access decisions for medical devices (through CE marking), making it easier to conduct HTA (see also Shatrov & Blankart, 2022; Wilkinson & van Boxtel, 2019).

The above highlights the power of dominant ways of seeing the future, as they shape expectations, that in turn shape the way MedTech is governed in the present. Chapter 5 similarly illustrated this dynamic when attempts to broaden the range of actors involved in HTA methodologies led to discussions that the proposed HTA methodologies were 'not really HTA'. Dominant framings can make it hard to imagine the present and future otherwise, especially so for actors who have ample experience with anticipatory practices (like HTA) in a certain way. Such path dependencies on previous solutions have been observed before, for example, in the governance of nanotechnologies: "When technological controversies erupt, the usual policy response has been to look for regulatory solutions based on familiar, science-based techniques", which are not always sufficient (Macnaghten et al., 2005, p. 282). In that case, the focus was on toxicity evaluations, however Macnaghten argues that other, more fundamental questions must also be addressed, such as 'Why these technologies? Why not others? Who needs them, and what human purposes are driving them?' Similarly, I argue that while an evaluation of the available evidence is an important element of governance, futureproofing MedTech governance also requires reflection on where dominant framings may exclude other important questions and approaches towards the future.

Contrasting approaches to the future

A review of academic literature on the subject reveals that currently, there are two contrasting approaches to the observed paucity of appropriate evidence for MedTech (Chapter 2). Discourse 2 (*HTA stimulator*) corresponds to the above expectation of more appropriate evidence in the future, arguing that HTA agencies can and should proactively stimulate the generation of more scientific evidence for MedTech. In Discourse 3 (*Convener*), a more recent discourse, such a lack of appropriate evidence appears to be interpreted as more of a given for MedTech. Here it is argued that HTA agencies

must work around this issue by engaging in participatory, experimental approaches with other stakeholders.

The conceptual framework of 4 different approaches to anticipatory governance adapted from Muiderman et al. (2020) and Uruena (2022) (see figure 1 in introduction) provides for an interesting analysis of these contrasting ways of dealing with a lack of appropriate evidence and uncertainty in MedTech governance. I would argue that 'Conventional HTA' aligns with anticipatory governance approach 1 (*Anticipatory governance to predict the future*), which assesses a probable future by analyzing patterns of the past (i.e., evidence), with the ultimate aim of risk reduction. The underlying assumption is that future risks and uncertainties can for a large part be made knowable, and that such knowledge can reduce uncertainty. The future is thus conceived as containing reducible risks, which can be acted upon in the present through knowledge infrastructures and expert-driven exercises. Approach 2 to anticipatory governance (*Anticipatory governance to strategically build capacity for the future*) encompasses cases where actors see more fundamental and irreducible uncertainties, which require other ways to explore the future, which are "[legitimized] through broad deliberation" (Muiderman et al., 2020, p. 8). To this end, a broader range of actors are included, including experts, policymakers and laypeople, to build capacity for reflexively navigating multiple plausible futures.

Experts dominate in conventional HTA, aligning with approach 1. But, in cases where the actors involved are of the belief that MedTech carries more fundamental and irreducible uncertainties, for which appropriate evidence is not always available or conclusive, approach 1 does not come to fruition and other methods to explore the future have to be sought. Methods that, as Muiderman (2020) states, explore the future through broad deliberation. Indeed, the literature on broadening HTA discusses involving patients (Gunn et al., 2021) or setting up early dialogues with regulators (Hogervorst et al., 2023) and industry actors (Ibargoyen-Roteta et al., 2022). It thus appears as though in cases where appropriate evidence does not exist for HTA to assess the value of a technology more reactively, i.e., in reaction to gathered evidence through expert-driven exercises, the positioning of HTA as an anticipatory practice changes from approach 1 towards approach 2.

This moving between approaches to anticipatory governance brings difficulties, which are already reflected in the literature on 'broadening HTA' (e.g., Alami et al., 2020; Bluher et al., 2019; Fuchs et al., 2017; Fuchs et al., 2019; Garfield et al., 2016; Tarricone et al., 2017). One of the ways difficulties are framed in such literature is as issues with 'normativity' (Bloemen & Oortwijn, 2024; Bloemen et al., 2024; Refolo et al., 2023; van der

Wilt et al., 2022). Looking at the difficulties through the conceptual lens of anticipatory governance adds an understanding to this, namely on the particular ways in which the future is 'normatively' envisioned. In approach 1, the future is envisioned as containing probable risks that should be reduced through extrapolation of evidence from the past. Inviting more stakeholders as a way to fill in the gaps or uncover unknown-unknowns that only emerge when perspectives intersect, changes this approach to the future. The goal becomes more in line with approach 2, which makes different futures plausible that cannot be reduced to a single, most-likely future. This requires a more reflexive engagement with the future, one that the current MedTech governance framework seems not sufficiently equipped with, at the day-to-day level.

Navigating different approaches to anticipatory governance

This leads me to my next contribution to literature on MedTech governance and HTA, namely a discussion of four difficulties I identified in navigating different approaches to anticipatory governance and how those appear to be affecting the MedTech governance landscape. Together, these show the politics of anticipation in practice, with potential effects on the MedTech governance landscape including frustration and withdrawal, role ambiguities, decision-deferral or incrementalism, and an anticipatory loop between public and private MedTech governance actors.

First, at the micro or day-to-day level, Chapter 5 on the ZonMw HTA program shows how managing divergent perspectives is highly complex and involves boundary work. During my observations, several scientists actually chose to withdraw from the program altogether, highlighting how this complexity can lead to frustration and withdrawal, which undermines the deliberation envisioned in approach 2 to anticipatory governance. This also illustrates that HTA, which is often framed as a rather systemic tool, is ultimately carried out between different actors with different interpretations of, and emotional investments in, what constitutes good governance.

Second, moving onto an institutional level, it seems that the different future visions in MedTech governance create potential institutional role ambiguities for HTA agencies. Chapter 2 highlights this ambiguity in current academic literature, where various discourses coexist on the role of HTA agencies in relation to MedTech. The discourses differ particularly in how agencies relate to other actors, leading to various possible structures for collaborative anticipation. The historically most dominant discourse (Discourse 1) presents HTA agencies as *independent evaluators*. Discourse 2 (*HTA stimulator*) frames HTA agencies as both evaluators and evidence stimulators, maintaining a certain degree of separation from industry but promoting engagement at the same time—this perspective has gained prominence over the last 15 years or so. Discourse

3 (*Convener*) positions HTA agencies closest to other stakeholders, as conveners facilitating deliberation among all stakeholders in a participatory and experimental manner, a view that has gained ground since around 2020. In addition, both these more recent discourses emphasize earlier involvement of HTA agencies, but with different goals. The HTA stimulator discourse aims to stimulate industry change (Blankart et al., 2021), while the Convenor discourse emphasizes mutual learning and adaptation (Leckenby et al., 2021). These different views of the future, combined with the increasing calls for proactivity, means that there are different potential roles for HTA agencies, highlighting possible institutional role ambiguities within the MedTech governance framework.

This institutional role ambiguity was not only evident from literature, but also in practice. For example, during the ZonMw HTA methodology program, ZIN played a central role in discussions about whether or not to fund a project. In discussions about grant applications, ZIN tended to reflect on whether the proposed HTA methodologies would be useful from their point of view. I argue that this is related to the role that ZIN is used to playing, namely that of an *independent evaluator*, taking a societal perspective. For MedTech, however, the situation in the Netherlands is as of yet such that reimbursement decisions are currently often made outside the Dutch HTA agency, e.g., at the level of health insurers, hospitals or by doctors. These stakeholders, who were also involved in the program, preferred methods that took their specific perspective into account, but discussions ensued about whether those were 'really' HTA. The actors involved in the ZonMw program thus seemed to struggle with the ambiguous current and potential future institutional role(s) of ZIN, in the context of MedTech governance.

Changing roles for HTA agencies are also occurring in pharmaceutical governance. For example, Chapter 1 explains how larotrectinib was granted market access by EMA based on phase 2 clinical studies (EMA, 2019). In fact, there is a trend of 'promising' pharmaceuticals proactively being granted market access by regulators (such as EMA) based on phase 2 rather than the standard phase 3 clinical studies (Detela & Lodge, 2019; Vokinger et al., 2022). Phase 3 clinical studies involve comparative analyses, which are necessary for more standard HTA methodologies (with a dominant example being cost-utility analysis) (Mills, 2023; Wolters et al., 2022). In the absence of such data, a blind comparison had to be made for larotrectinib, populating the cost-utility model with previously published evidence for the comparator arm. In response, ZIN could not conclude its role as an independent evaluator, but adopted the role of HTA stimulator, in the form of conditional reimbursement, i.e., reimbursement based on the condition that additional evidence be collected (Zorginstituut, 2024b). For larotrectinib, the conditional reimbursement scheme eventually led to a new assessment module for assessing tumor-agnostic therapies (Zorginstituut, 2023b) and sufficient reduction of uncertainty

to achieve consensus on its inclusion in the basic benefits package. It seems, however, that for innovative MedTech, consensus is often not reached, prompting discussions around other, more experimental roles for HTA agencies. These institutional role discussions persisted, at least during the time of writing of this dissertation.

Third, moving onto more procedural impacts, I highlight how the coexistence of diverse anticipations in practice often leads to decision-deferral, or at least incrementalism (Migone & Howlett, 2016), potentially fragmenting the MedTech governance landscape. For example, the international MedTech horizon scan did not explicitly choose between diverse visions of the future (which I conceptualized as micro-regimes of anticipation). Instead, the current plan for the MedTech horizon scan is that it will be tested out in smaller steps, starting with a feasibility study, followed by a small pilot, a basic system, and subsequent expansion. The ZonMw program also divided funding decisions into several rounds, which some participants found frustrating because they felt it unnecessarily complicated the decision-making process. What's more, participants mentioned that discussions about HTA methodologies for MedTech had been going on for a long time, without a clear vision for the future emerging. This worried them, as became evident in Chapter 5 where one of the quotes reads: "We don't seem to be getting anywhere in these discussions, and with the problems we face, we don't have much time left." This aligns with other, practice-based research on MedTech governance, which emphasizes that rather than committing to a single vision of the future, the future is continuously tested out in smaller increments (Carboni, 2024), which means that the MedTech governance framework remains fragmented, temporary and 'tentative' (Kuhlmann et al., 2019).

Fourth, zooming out to broader, international impacts, the findings allude to how a compounding of anticipation between public and private actors (the anticipatory loop) influences the MedTech landscape in terms of innovation and equity. I argued how this anticipatory loop leads not only to the already well-known pacing problem, conceptualized as a growing gap between the development of innovative MedTech and their governance (Marchant et al., 2011; Wallach et al., 2018), but also to what I called a 'reverse pacing problem', i.e., a growing gap between the implementation of governance policies and industry actors' implementation of them, which appears especially problematic for smaller industry actors (start-ups and scale-ups). Smaller actors seem to have less 'anticipatory agency' (Ahlqvist et al., 2012) available to grasp and undertake the anticipated future. In response, industry often elected to launch more simplified versions of their innovations, to launch their products in other geographical areas instead, or to withdraw their products from the market in anticipation of more stringent regulations. What's more, less regulated areas where industry relocates risk becoming

unofficial 'sandboxes' for experimentation with innovative products. This highlights that differences and uncertainties in future visions between private and public actors, encapsulated in the anticipatory loop, have the potential to change MedTech landscapes in terms of innovation and international equity.

Finally, I also identified two underexplored approaches to anticipatory governance, namely those aimed at collectively imagining diverse futures and broadening imagination (A*pproach 3*) and those aimed at critically analyzing anticipatory practices (A*pproach 4*). Such approaches more explicitly deliberate on the 'openness of the future' and the political and performative dimensions of anticipatory practices. The dearth of these approaches in the context of HTA and HTA agencies is mirrored in literature on anticipatory governance in the context of sustainability (Muiderman et al., 2022). In both climate and MedTech governance contexts, the more technocratic approach 1 seems more fitting to current policy frames and linear planning focusing on risk mitigation. Approach 2 (*Anticipatory governance to strategically build capacity for the future*) is gaining recognition in both contexts, but the implications are harder to connect to their policy frames and planning styles. I make the case for a proliferation of these underutilized approaches to anticipatory governance in the context of HTA and HTA agencies. My findings underline that MedTech innovation, HTA and governance are not only technical issues, but have socio-political aspects with far-reaching implications (Bloemen et al., 2024; Refolo et al., 2023; van der Wilt et al., 2022; Wehrens & de Graaff, 2024). Incorporating anticipatory practices that are more geared towards 'imagining otherwise' may help in efforts to futureproof MedTech governance, laying bare the socio-political dimensions that are inherent to socio-technical systems, and are therefore a powerful potential tool for creating reflexivity.

Sub-conclusion

In conclusion, I highlight how expectations around 'conventional HTA' have created dominant framings of how MedTech governance is imagined in the present, making space for aspirational evidence that often does not come to fruition. At the same time, responses that are moving from anticipatory governance Approach 1 (*Anticipatory governance to predict the future*) to Approach 2 (*Anticipatory governance to strategically build capacity for the future*) are increasingly being experimented with, stipulating 'broad deliberation' between multiple stakeholders.

However, introducing more stakeholders as a way of dealing with uncertainties also means introducing more visions of the future, further politicizing decisions about which future to focus on. These 'politics of anticipation' appear to be impacting the MedTech governance landscape in different ways; causing frustration at the micro-level

with potential for opt-out by certain important actors; triggering potential institutional role ambiguities; leading to decision deferral that potentially fragments MedTech governance processes; and potentially impacting innovation and international equity through the workings of an anticipatory loop. Finally, I identify an underutilization of more reflexive and critical anticipatory practices in MedTech governance, more in line with anticipatory governance approach 3 and 4, which I hypothesize to be a powerful potential tool for creating reflexivity in MedTech governance and HTA.

Research aim 2: Enriching Anticipatory Governance through MedTech Policy Practices and Discourses

Moving onto my contributions to the anticipatory governance literature, I show that in practice, stakeholders are increasingly called upon to collaborate in MedTech governance. This corresponds with normative anticipatory governance literature, which generally posits that some of the issues with anticipating the future should be managed by involving a diverse group of actors in anticipatory practices, further democratizing governance of the future (Barben, 2008; Guston, 2014; Ozdemir et al., 2011; Zaratin et al., 2022). It is most in line with Approach 2 to anticipatory governance (*Anticipatory governance to strategically build capacity for the future*), which generally stipulates anticipatory governance through an ensemble of foresight, engagement, and integration (Guston, 2014) or collective steering (Ozdemir et al., 2011). While the theoretical rationale for inclusion and integration of different disciplines and stakeholders is well established in the anticipatory governance literature (and beyond), limited attention has been paid to the political and practical aspects of 'doing' inclusion and integration in the anticipatory practices of MedTech governance.

In particular, my findings provide an important, critical reading of more normative anticipatory governance literature. The findings of this dissertation highlight how collaborative anticipatory governance in practice leads to boundary work with significant affective dimensions; a reflection on which is missing, or is at least underexposed, in existing literature. Importantly, as highlighted in the previous section, I also show that in the relative absence of options for engagement and integration, stakeholders anticipate each other, resulting in a compounding of anticipation that I conceptualized as the anticipatory loop. Thus, my point is not to negate the potential of engagement and integration in MedTech governance, but rather to stipulate that a number of criteria be met, which should be further teased out in future anticipatory governance research. In what follows, I will discuss my contributions to the anticipatory governance literature in more detail.

Boundary work and emotion in collaborative anticipatory governance

First, the inclusion of a broader range of actors in HTA does not inherently lead to integration or collective steering, and involves highly affective boundary work. Chapter 5 highlights that while the actors involved in the ZonMw HTA methodology program generally agreed that conventional HTA methodologies were not always fitting for MedTech, they differed on the extent to which HTA methodologies should be adapted, who should be involved in doing so, and how those professionals should collaborate. From my observations and interviews, I constructed three interpretations of HTA—traditional, participatory and exploratory—each with different implications for stakeholder collaboration and integration, conceptualized as 'Collaboration hybrids'. I make the case that in grappling with these different options for integration, actors engaged in boundary work. Interestingly, such boundary work seemed to have considerable affective dimensions, such as (mis)trust, frustration or concern, highlighting that stakeholders bring personal values and emotional investments to their collaborative anticipatory governance efforts.

Similarly, the diary entries of myself and two other PhD students analyzed in Chapter 6 show that in practice, the transdisciplinary and interparadigmatic (T/I) collaborations initiated in MedTech governance require translation practices that have considerable affective dimensions, such as feelings of exclusion, worries about the future, or frustration. Such T/I PhD projects are composed of actors and institutions with different conceptions of what constitutes knowledge and knowledge making. This means that PhD students have to engage in boundary work in the form of various, mostly invisible translation practices, in order to navigate between different groups and ways of knowledge making, with the diary entries highlighting the emotional labor involved in doing so. On a hopeful note, it is conceivable that in the future such T/I PhD projects will give rise to (or empower) a new type of actor, one which embodies the integrated T/I approach, with potential benefits for (research on) the future governance of MedTech. However, the present moment reveals that such affective dimensions appear to complicate the collaborative anticipatory practices of MedTech governance, thus contradicting the promises made in the normative anticipatory governance literature, as well as the objectives of T/I PhD projects, which generally posit that the T/I approach will work to address the 'wicked problems' in MedTech governance (e.g., Rylance, 2015).

An important emotion that influenced the collaborative anticipatory practices of MedTech governance was (mis)trust, for example in the complicated participation of private MedTech industry actors. Their inclusion in the ZonMw program was met with a degree of caution by several participants, who anticipated that HTA methodologies risked becoming a marketing tool if industry actors were to be involved in their development.

Similarly, Chapter 3 showed how some participants in the horizon scanning tool also expected mistrust from industry in return. As participants argued, such mistrust would make it difficult to populate the tool with information relevant to the HTA micro-regime, as such information is often not publicly available for MedTech, and some information may need to be requested from industry actors. Chapter 4 further discusses how mistrust has been exacerbated by semi-recent MedTech scandals such as leaking breast implants (Deva et al., 2019), hip implant erosion (Wienroth et al., 2014), or the recall of potentially unsafe respiratory devices (Owens et al., 2021), with one industry actor stating that public and private governance actors are now in 'foxholes' constantly defending themselves.

The complex relationship between trust and regulation has been extensively theorized in public administration and other literatures (Bareis, 2024; Oomsels & Bouckaert, 2014; Poppo et al., 2008; Six & Verhoest, 2017), but seems underexplored in the AG literature, where uncertainties pervading future expectations seem to complicate matters further. Where trust is lacking, anticipatory efforts may inadvertently create a cycle of uncertainty rather than reducing it, as highlighted in the concept of the anticipatory loop, potentially leading to a strategic compounding of anticipation and mistrust. An example can be seen in the introduction of the MDR. One change in the move from the previous MDD to the new MDR was the removal of advice-giving by notified bodies, seemingly in part due to a lack of trust that such services would not be misused by industry actors. In response, several MedTech industry actors removed their products from the European market until the impact of this regulation becomes clearer. These actions, in turn, seem to lead to more uncertainty and heightened mistrust on both sides of the public-private governance divide. Thus, collaboration in anticipatory practices requires trust, and attention must be paid to the socio-political dynamics and trust-building necessary to foster sustainable collaboration.

Finally, my findings highlight that not every stakeholder has the same amount of space for anticipation. Mostly larger MedTech companies have the anticipatory agency (Ahlqvist et al., 2012) to reorganize to focus more on anticipatory practices. For instance, HTA departments within larger Medtech companies and advisory agencies play an active role in shaping regulatory dossiers, advising on aspects such as the indication, outcome measures, and target populations, well beyond simply interpreting trial data (Hogervorst et al., 2025). Some larger companies (including Microsoft, Google, and Amazon) may even be in a potentially more powerful position than public governance actors because of their size. This means that governance is increasingly undertaken by private MedTech actors, who in the current system are necessarily driven by market logics. However, rather than casting "boogeymen" or defending from foxholes, I argue

that it is more productive to recognize that these actors are intertwined. As my studies show, anticipatory MedTech governance is ultimately carried out between different actors with different interpretations of and emotional investments in what constitutes good governance. For the anticipatory governance literature, I argue that this *boundary blurring* then specifically begs the question how anticipatory practices could be structured in ways that public governance actors as well as smaller private governance actors stand a chance against Big(ger) Tech (Passchier, 2025), on which I will reflect further in my suggestions for future research.

Reflexive space

The different chapters of this dissertation collectively point to the importance of scaffolding reflexive space (Wiig et al., 2021) that supports both practical and emotional aspects of collaborative anticipatory practices, and for making the different expectations of different actors explicit. Successful examples of anticipatory governance, as observed by Barben et al. (2008), often depend on enhancing actor reflexivity. Bray (2018) similarly notes that without reflexivity, even well-intentioned stakeholder engagement can leave participants dissatisfied. I argued in Chapter 4 how public governance actors appeared to build trust and reflexivity mainly at macro levels, within regulations and policy frameworks that focus on governance processes being auditable and transparent. Participants expressed, however, that it also required changes at micro and meso levels. Several participants expressed hope that building reflexive spaces at micro and meso levels would help to alleviate some of the uncertainties in MedTech governance. A potential example from Dutch practice are the deliberation opportunities offered at Zorg voor Innoveren (https://www.zorgvoorinnoveren.nl/), however, more research into the way deliberation plays out in practice would be necessary here.

Importantly, my findings show that although important, establishing temporary reflexive spaces alone is insufficient. To cope with uncertain futures, there is a desire for both experimentation and standardization. Participants emphasized that temporary, experimental anticipatory practices, such as pilot projects, often fail to transition into more long-term, standardized governance frameworks. Instead of "moving between different spaces and translating from the local to the global," as Alvial-Palavicino's (2015) puts it, they remain 'tentative', existing as an "intermediary space" (Ryghaug & Skjølsvold, 2021, p. 56). Thus, although constructing reflexive spaces allows for exploration and learning, translating insights into standardized, more institutionalized governance practices seems difficult, and embedding reflexivity into more standardized anticipatory practices seems just as important as constructing reflexive spaces for experimentation.

However, my studies also show that actors who are used to dealing with anticipatory practices in a certain way find it challenging when these anticipatory practices are adapted. As my case-studies show, the more institutionalized anticipatory practice of conventional HTA is then difficult to 'open up' to reflexivity. This led to methodological diversity, epistemic conflicts and communication barriers. This is not inherently bad; in fact, it is part of the goal of institutionalizing an anticipatory practice that it becomes more embedded and entrenched. For both public and private actors, this helps to stabilize the governance framework and reduce uncertainties. As one interviewee in chapter 4 said, it allows for more 'plannable uncertainty'. However, when institutionalized anticipatory practices are no longer 'fit for purpose' (Mathews et al., 2022), in other words, when they can no longer manage the uncertainty for which they were developed, new ways of engaging with anticipatory practices will be necessary.

This highlights the complex nature of anticipatory practices. The challenge lies in the conflicting desires to institutionalize and formalize these elements while maintaining flexibility and reflexivity in response to an uncertain future (see also Clegg et al., 2005). I show how this in practices creates new uncertainties, leading some actors to argue for closing the governance framework and sticking to what is (*boundary closure*) and others to make a case for developing something entirely new (*boundary blurring*). I argue that anticipatory governance of MedTech will likely require a cycle of experimentation and standardization. I make the case, however, for more attention to building reflexive space into both the existing, business-as-usual practices of MedTech policy as well as into the experimental spaces, with more attention paid to the inherent boundary work and its affective dimensions in anticipatory governance.

Sub-conclusion

In conclusion of research aim 2, my empirical case studies underscore the practical intricacies involved in broadening stakeholder involvement in an effort to futureproof MedTech governance. Understanding these aspects is critical to determining whether and how stakeholder inclusion (or exclusion) contributes (or does not contribute) to anticipatory MedTech governance, and as such provides an important contribution to the anticipatory governance literature. Collectively, my findings caution against oversimplified assumptions about inclusion in the practices of anticipatory governance, such as observed in Guston's (2014) assertion that the inclusion of voices "*bends the long arc of technoscience toward more humane ends*" (p.234).

Instead, effective anticipatory practices require deliberate attention to the processes of inclusion (Hajer & Versteeg, 2005) and raise otherwise, well-known issues such as that of representation and undue influence. In particular, the findings highlight how

collaborative anticipation warrants creating reflexive space for inherent boundary work into the current practices of MedTech policy making, with attention to affective dimensions. I also raise questions about the relation in anticipatory governance between experimental and standardized anticipatory practices. I will reflect on these findings and their implications for future research in the next section, where I will return to answering the main research question posed in this dissertation.

Main question: How are anticipatory practices shaped by and shaping the governance of MedTech?

This dissertation provides insight into how anticipatory practices are shaped by and shaping the governance of MedTech. Currently, anticipatory practices in MedTech governance seem primarily aimed at predicting the most likely future, by extrapolating from past evidence, through expert driven knowledge infrastructures, in line with anticipatory governance approach 1. This preference seems built on previous experiences with anticipatory practices in the context of other technologies, mainly pharmaceuticals, which seem to guide anticipation and ways of framing the present, creating dominant ways of seeing the future that make it difficult to imagine anticipatory governance of MedTech 'otherwise'. Whilst for some MedTech innovations, this dominant approach allows for a meaningful reduction of uncertainty (Zorginstituut, 2018, 2020c), for many, it proves insufficient. In response, and seemingly as a way to navigate these difficulties, more multidisciplinary or collaborative anticipatory practices in MedTech governance are increasingly being experimented with, in line with anticipatory governance Approach 2. I also identified two anticipatory approaches that seem underexplored as of yet, namely those aimed at collectively imagining diverse futures and broadening imagination (*Approach 3*) and those aimed at critically analyzing anticipatory practices (*Approach 4*).

This dissertation shows the challenges of moving between different futures orientations in MedTech governance. I showed how coexisting and conflicting future visions lead to stakeholder frustration, institutional role ambiguities, decision deferral, and impacts on innovation and international equity. I also reflected on the boundary work inherent to doing so. This boundary work had considerable affective dimensions, highlighting how anticipatory practices in MedTech governance efforts are ultimately carried out between different actors with different interpretations of, and emotional investments in, what constitutes good governance. Finally, I showed that in the absence of reflexive space for such boundary work, stakeholders anticipate each other, conceptualized as

an anticipatory loop between public and private governance actors and the (reverse) pacing problem, both characterized by mistrust.

Overall, my findings illustrate the complexities of collaborative anticipatory practices in MedTech, exacerbated by the politics of anticipation. However, they do not mean that collaborative anticipatory practices are ineffective or unhelpful in MedTech governance. Rather, I would argue that their goals should be reconsidered. Such collaborative anticipatory practices are often framed as ways to accelerate decision-making. For instance, the ZonMw HTA methodology gap analysis emphasized the value of bringing together stakeholders from policy, practice, and research "so that all aspects can be examined from a common vision and implemented in the short term" (UMC, 2021). My case studies show that such collaborations often produce new uncertainties before reducing them. Instead of striving for "clear language, unambiguous goals, bold agreements and consensus" (Zorginstituut, 2020b), I suggest that these practices should instead strive for enhancing reflexivity, on which I reflect more explicitly in the sections on suggestions for future research and policy recommendations.

I found limited space for and guidance on reflection in the anticipatory practices I followed. At the moment, I would argue that the absence of such guidance and spaces for collaborative reflection are leading to the pacing problem as well as the reverse pacing problem, which together create and further excavate a gap or vacuum in the governance framework. Because governance frameworks generally do not allow for a vacuum (Harari, 2017), other forces come in and fill this gap. I find that this gap is increasingly being filled by private governance actors, especially so-called Big Tech companies, which necessarily focus on market values and do not always consider broader public values. Therefore, I argue that it is essential to deliberately and intentionally scaffold reflexive space into the anticipatory practices of MedTech governance, where multiple perspectives can shape the trajectory of innovation.

Suggestions for future research

Overall I argue that the insights gathered in this dissertation make a case for broadening reflexivity in the anticipatory practices employed for MedTech. Luckily, much like the anticipatory governance literature offers ways to analyze MedTech governance, it also offers potential ways to create anticipatory practices that introduce more reflexivity. With regards to research aim 1, I urge future research to explore anticipatory practices that are more in line with anticipatory governance approach 3 (C*ollectively imagining diverse futures and broadening imagination)* and 4 (*Critically analyzing anticipatory practices*). Examples of anticipatory practices in line with approach 3 include simulation gaming and exhibitions that create 'experiental futures' (Candy &

Dunagan, 2017; Hajer & Versteeg, 2018; Vervoort, 2019) or scenario workshops aimed at unlearning (Burt & Nair, 2020; Chimal & Ramos, 2024). These anticipatory practices especially emphasize the importance of embodied, experiential, and experimental futures practices that foster deeper engagement. Simulation games exemplify this potential, functioning as "sites wherein the politics of imagining and anticipating the future can be analyzed. " (Vervoort & Gupta, 2018, p. 105). These types of anticipatory practices could help stakeholders imagine and acknowledge unintended consequences and reflect on their underlying assumptions (Bengston et al., 2012).

With respect to critical reflection (*Approach 4*), the focus is not on different types of anticipatory practices, but on ways of organizing them (Muiderman et al., 2020). Mostly, literature that fits approach 4 argues that anticipatory practices should provide space for reflection on the methodologies and assumptions behind the techniques of anticipatory practices (such as HTA). This could foster questioning of political implications of future visions and pathways for the present, potentially interrogating dominant framings of the future (Selin, 2008). Examples include integrative deliberations or vision assessments (Mittelstadt et al., 2015; Selin, 2008), where foresight methods are envisioned that more clearly show whose values shape the way the future is envisioned, all stakeholders are invited to voice their normative concerns about the future, reframing anticipatory governance as an ongoing democratic process rather than a technocratic prediction tool.

While anticipatory practices such as integrative deliberations or vision assessment may sound futuristic or abstract, opportunities are already present in current MedTech governance and HTA. A potential site for deliberation is the HTAi Global Policy Forum, which operates under the Chatham House Rule and aims to provide a 'safe space' where HTA agencies, industry actors and patient representatives meet annually to discuss critical issues, such as inter-organizational collaboration (Trowman et al., 2024). Another example is EMA's parallel consultation procedure (e.g., parallel scientific advice with HTA bodies), which allow early dialogue between industry actors, regulators and HTA agencies, but primarily focus on aligning evidentiary expectations rather than inviting broader societal deliberation (EMA, nd). Such spaces are valuable for coordination and alignment, yet they currently still tend to privilege expert and institutional viewpoints, and rarely engage with wider publics or with more speculative, justice-oriented questions about what kinds of futures are being enabled or foreclosed. Future research should focus on these spaces and similar ones to critically examine how they function as reflexive spaces and to explore their potential for incorporating more imaginary and critical reflexive ways of engaging with the future.

Finally with regards to research aim 1, an important topic for further analysis is how my studies within the Western governance context highlight the issue of anticipatory dynamics that motivate MedTech companies to test technologies in areas with less stringent MedTech regulations. This is something that several other scholars have recognized in terms of a 'colonization of the future', and a critical interrogation of whose future is at stake in most of the anticipatory governance literature (Maccaro et al., 2022; Mitchell & Chaudhury, 2020). I therefore specifically urge future research on anticipatory governance of MedTech to focus on non-Western contexts, building on insights and reflections from such research in the context of climate governance (Gram-Hanssen et al., 2021). Muiderman and others (Muiderman, 2022; Muiderman et al., 2023) have also shown that while approaches in the context of climate governance often follow more technocratic visions of the future, several examples (e.g., from Costa Rica) highlight the potential for more transformative visions of the future by incorporating other ways of knowing the future, e.g., from indigenous communities. This highlights that other contexts may have more space to imagine the future otherwise, perhaps because they feel the impacts and pitfalls of the current approaches more acutely (see also Mitchell & Chaudhury, 2020). Such policies and dialogues then explore 'what could be' rather than just 'what is likely', which I argue is not only relevant in climate governance, but highly relevant for MedTech governance as well, not least because the two are highly interrelated, e.g., in terms of shared concerns over sustainability and equity.

With regards to research aim 2, I highlighted the importance of reflexive space for inherent boundary work in anticipatory governance. Some could argue that foregrounding the creation of reflexive spaces in anticipatory governance poses challenges in terms of the risk of lobbying or other types of harmful industry influence. In the absence of trust and with the risk of lobbying, reflexive spaces are thus difficult to create for anticipatory (MedTech) governance. However, reflexive spaces could also serve as a counterweight to behind-the-scenes lobbying, forcing public discussion and accountability and working against regulatory stagnation as reflexivity increases responsiveness. While any governance mechanism carries risks, I argue that reflexive anticipatory spaces could offer an alternative to purely adversarial or siloed approaches. To counteract lobbying, and to achieve reflexive space responsibly, I do argue that they should be designed with safeguards in mind, such as diverse participation (including academia, civil society, and large and small firms) to reduce the risk of regulatory capture (de Graaff et al., 2024), and mandatory documentation of discussions and decisions to increase transparency and accountability. Such spaces should then also be closely monitored in future anticipatory governance research, asking questions such as: Why is a foresight process undertaken, how is the future conceptualized? Who funds, designs, and leads

these practices? Who participates, and who is excluded? What implicit assumptions shape the design and outcomes of these practices?

Another question on reflexivity I wish to engage with is who is responsible for organizing reflexive space in anticipatory governance. Should there be an assigned convenor, and who is equipped for this role (in the Netherlands as well as abroad)? This role is encapsulated in the concept of a boundary organization. The role of boundary organizations to stimulate a supportive environment is already highlighted in literature on anticipatory governance as well as on HTA (Gauvin et al., 2010; Husereau et al., 2016). Overseeing which actors have a voice in the future is important, as evidenced by anticipatory governance literature (Robertson, 2022) as well as participation literature (de Graaff et al., 2024). Boundary organizations are sometimes even called 'guardians of the future' (Robertson, 2022). HTA agencies are positioned as potential boundary organizations. However, this role would likely further complicate the already complex role of HTA agencies. Organizing reflexive space is a time-consuming practice, including the capacity to reflect on one's own work (de Graaff et al., 2024). Are HTA agencies sufficiently equipped for that? I urge future research to explore the complex, institutional role of HTA agencies, especially in light of my earlier call for increasing reflexivity.

Another important question for the anticipatory governance literature relates to the observation that not every stakeholder has the same amount of space available for anticipation, with larger industry actors in a potentially more powerful position than national public governance agencies. Who is currently futureproofing MedTech governance through anticipatory practices, and to what ends? I specifically urge future research to pay more attention to a blurring of boundaries in MedTech governance in and by anticipatory practices. What does this mean for the anticipatory governance of (Med)Tech, and how could anticipatory practices could be structured in ways that public governance actors as well as smaller private governance actors stand a chance against Big Tech?

Finally, while my ethnographic findings provide insight into the places where anticipatory practices do occur, they inherently do not cover the perspectives of stakeholders who were not involved. Furthermore, they cover the types of anticipatory practices that seem to dominate in the current policy framework, namely those that aim to predict the future or strategically prepare for the most plausible future (in line with anticipatory governance approaches 1 and 2, respectively). As a result, certain perspectives or types of anticipatory practices that imagine the future 'otherwise' remain underexplored here. I have already reflected on the importance of missing actors in anticipatory practices and the potential of other types of anticipatory practices with a different

orientation to the future. Acknowledging these gaps highlights the limitations of my findings and underscores the need for future research to focus on different types of anticipatory practices and perspectives to hopefully provide a more complete picture of the anticipatory governance of MedTech. Specifically, I urge future research to explore the perspectives of patients, private payers, or health insurers. Similarly, research conducted within hospitals and closer observation of Notified Bodies in practice could further enhance the picture and add to anticipatory governance literature. In addition, the role of Dutch municipalities, particularly in light of the 'Wet Maatschappelijke Ondersteuning' (Social Support Act), warrants further investigation, especially with regard to the complicated distinction between 'health-oriented' technologies (MedTech) and wellness-oriented MedTech, and the implications and complications of such a distinction.

Policy recommendations

ZIN is increasingly asked to 'think ahead' and to explore a more proactive role in MedTech governance (as well as beyond, e.g., Van de Sande, 2023). Since its inception, ZIN has 'looked to the future' of health technologies. Increasingly, however, it is being asked to anticipate broader developments for MedTech. At the same time, it is expected to translate findings into an integral assessment framework. What's more, ZIN is increasingly asked to do so in collaboration with other stakeholders. As the case studies in this dissertation highlight, coexisting and sometimes conflicting visions of the future make collaborative forward thinking difficult. Other research on ZIN has similarly shown that the involvement of external parties adds to the complexity and causes delays and uncertainty (Van de Sande, 2023). As the institute struggled to define its role in MedTech governance, it posited this struggle as a question for its academic collaboration, AWVZ, culminating in this dissertation.

Looking at the studies in this dissertation, one can find diverse expectations about the (future) role of ZIN. Diverse expectations make the role of ZIN complex. Nevertheless, I conclude that the complexity of MedTech governance indeed ask of ZIN to adopt different roles in different contexts. This will require more explicit choices on the part of ZIN. I reiterate that those choices are highly political: Focusing on one thing means not focusing on others. Deciding which role to focus on in which contexts can affect how (and which) MedTech are identified, classified, evaluated, procured, distributed, regulated, dismissed, or neglected. These role choices therefore require careful attention and reflection.

To this end, I will briefly reflect on three different ideal-typical roles for ZIN in future-proofing MedTech governance—as identified in the discourse analysis of Chapter 2—

and the recommendations for such roles that emerge from this dissertation, giving examples from relevant policy documents. I will then reflect on an additional, more transcendent role, one which encapsulates the two more critical discourses of Chapter 2 as well as findings from the other studies in this dissertation. Finally, I will zoom out to consider the relevance of these recommendations for other HTA agencies.

Independent evaluator

Looking at policy documents, one can find various proposals that seem to foreshadow a future role for ZIN as a more independent evaluator of MedTech. In November 2020, VWS discussed in parliament the possibility of introducing a lock-procedure for MedTech as well as the potential for a MedTech horizon scanning tool, both similar to the ones already in place for pharmaceuticals (TweedeKamer, 2020). As reiterated throughout this dissertation, experiences with pharmaceutical governance steer expectations for MedTech. However, this role as a formal, independent evaluator does not seem to come to fruition in the Netherlands. The lock-procedure for MedTech was not established (Berenschot, 2021). Abrishami (Abrishami, 2018) previously showed how ZIN struggles to define the parameters of affordability, quality, and accessibility for MedTech, and therefore could not take on this role. In practice, I have shown how the clash between this desired or expected role of an independent evaluator and the current reality of a lack of evidence often leads to postponement of decisions, frustration and increased uncertainty.

I argue that barring a major overhaul of the system (such as happened around the introduction of the ZVW in 2008), it is unlikely that the role of an independent evaluator of Medtech, following an integrated assessment framework that applies to all technologies, is going to happen in the future. In theory, JCA by HTA agencies, as stipulated in the HTAR, could be seen as an execution of this role. It frames the harmonization of assessment methods on which decisions are based as both achievable and part of the role of HTA agencies. In practice, however, these processes clearly distinguish between those for pharmaceuticals and those for MedTech and inherently add the role of HTA stimulator in their efforts to support evidence planning for MedTech, which I will discuss in more detail in the next section.

HTA stimulator

Many policy documents describe a role for ZIN that is in line with what I have called an HTA stimulator in Chapter 2. For example, in august 2020, ZIN published an indication report on TAVI, a MedTech innovation for patients with aortic valve problems (Zorginstituut, 2020c). The report emphasizes that the committee has been more 'mild' than in the case of expensive pharmaceuticals, and that it is important to collect evidence on

the cost-effectiveness of 'non-pharmaceuticals' in order to more systematically assess the societal relevance of these technologies in the future (p. 77). In the case of JCA, early dialogues are a core tool mentioned in the HTA regulation to support evidence planning (EU, 2021b). This role thus encapsulates both stimulation of HTA evidence as well as stimulation of HTA methodologies that fit MedTech.

However, because ZIN currently does not have a standard role in the evaluation of MedTech, MedTech innovations are typically already deeply embedded within health care systems before ZIN is called upon. Changes from an authoritative standpoint are difficult at that point, as the aforementioned Collingridge dilemma and Technological momentum highlight. What's more, calls for further evidence generation often do not result in reduced uncertainty, as conflicting evidence often exists (Abrishami et al., 2020). Furthermore, it is difficult to be a dialogue partner around evidence that one later has to evaluate, as ZIN fears setting precedents.

Therefore, I recommend boundary spanning practices for this role, as elaborated on in Chapter 5, to help actors speak the same language and develop shared objectives. Currently, such boundary spanning practices are actually increasingly being removed from areas of MedTech policymaking, as evidenced by the removal of advice-giving by notified bodies (Baines et al., 2023), or the installment of strict conflict of interest rules in the HTAR (Gentilini & Parvanova, 2024; Julian et al., 2025). However, without such opportunities, only companies that have the capital to develop 'sufficiently robust' evidence as well as those governments that have the resources available to assess such evidence will be able to meet demands, raising aforementioned issues with international equity and innovation.

Convener

As HTA agencies do not have the resources to govern the vast number of MedTech alone, they increasingly need to collaborate with others. An example from the policy domain for the role of convenor is found in a ZIN report from August 2020, which discusses the lessons learned from the introduction of the Da Vinci robot, a MedTech that assists in surgery (Zorginstituut, 2020a). They conclude that the evaluation of MedTech innovations like the Da Vinci Robot should be done together with all relevant stakeholders, at an early stage, in a continuously ongoing and flexible dialogue. My findings highlight, however, how path dependencies with previous roles make it hard for both people working at ZIN as well as other actors to see ZIN in this role of a convener. In addition, it is questioned in the literature whether a historical commitment to neutral evidence may conflict with this role (Bloemen et al., 2024).

I argue that this role encapsulates a different relationship to uncertainty than ZIN is used to taking in the context of HTA. Compared to the role of HTA stimulator, this role positions ZIN more alongside other stakeholders, foregrounding interaction and deliberation. I argue that a certain level of boundary blurring will be necessary in this context, giving participants from practice a more deliberate role. Although this dissertation also highlights a level of resistance to this role, it is not entirely new to ZIN. In their work around quality of care, they do work with pioneers (*kwartiermakers*) who bring parties together to arrive at standards (Van de Sande, 2023). I therefore recommend ZIN to build on experiences in that context.

Additional role: Scaffolding reflexivity

Adopting different roles in different contexts is complex. In spaces where ZIN acts as an independent evaluator, they are no longer a neutral convener, whilst wanting to be a conversation partner risks setting precedents that limit their role of being an evaluator. Therefore, ZIN should reflect internally and together with VWS on where to take which role, and who to position where. For example, whereas for conditional reimbursement a role as HTA stimulator seems more appropriate, in cases where the evidence base contains contradictions or where multiple perspectives intersect, the role of convenor seems more fitting. To move between different roles, competencies such as relationship-building and reflexive dialogue are just as important as already more established competencies like evidence assessment.

This brings me to an additional, transcending role, in scaffolding space for internal and collaborative reflection. It seems that reflexive capacities can be improved for ZIN and HTA agencies more broadly. Chapter 2 identified two critical perspectives on the role of HTA agencies, namely in terms of limited reflection on normativity and on their level of clinical expertise. In chapter 3, I further highlight how there is currently limited explicit reflection by public governance agencies (like HTA agencies) on who is involved in futureproofing MedTech governance, and what this means for who has a voice for making the future. Again, this role is not entirely new for ZIN. ZIN already engages in several anticipatory practices to increase reflexivity, for example through the academic collaboration that this PhD project was a part of. I would argue that the difficulty lies in the fact that ZIN has to re-imagine and 'renovate' while at the same time 'keeping their shop open'. This creates some of the institutional ambiguity that I have identified in this dissertation. As a result, and as is common for experimentation, HTA agencies' experiments are often placed outside of the business-as-usual departments, e.g. in the HTx collaboration (EU, 2025), the NICE HTA lab (NICE, 2025), or the research for this dissertation. Although this is a logical solution, I show that in practice the perceived discrepancies between business-as-usual and experimentation can lead to frustration

among actors involved, who either see anticipatory practices as being developed too broadly or as developing too little. I find that ZIN has a role to play in managing such conflicts, not least through increased communication with the other stakeholders, so that these innovative spaces do not run too far ahead of the crowd, without opportunities to catch up. If such differences are not managed appropriately, there is a risk of losing key actors from the polycentric regime of MedTech governance.

Zooming out

The extent to which these recommendations apply to other HTA agencies will depend on the specific ways in which HTA and MedTech governance are organized. Overviews exist in the literature, but because MedTech governance is a dynamic system, they are outdated quickly (e.g., Bluher et al., 2019; Ming et al., 2022). I find my findings on scaffolding reflexivity to be particularly important, and to have the most potential to traverse the specific study context of this dissertation. Especially in light of the observed trend in the introduction, in terms of calls for broader, long-term perspectives on the deeper implications of emerging technologies combined with an increasingly short-term focus characterized by a sense of urgency and lack of control. This dual reality is encapsulated in the increasing calls for iterative or cyclical HTA that attempts to adopt both a shorter and a longer term perspective. With the observed scarcity of evidence surround MedTech, the normative complexity of what HTA agencies should and should not do seems to be increasing (Bloemen et al., 2024). And in light of the JCA of certain high-risk medical devices mandated from 2030 onwards, this normative complexity of the work of HTA agencies regarding MedTech may further amplify, bringing discussions 'above the surface' (Syrett, 2003).

Therefore, I wish to conclude my policy recommendations with a more general call for HTA agencies to enhance reflexivity. Anticipatory practices such as horizon scanning and HTA are increasingly being used as tools of governance, as a form of 'governance by anticipation' (Konrad & Alvial-Palavicino, 2017). Equally important is 'governance of anticipation', which asks the question: Who governs the ways in which futures are imagined or projected, how are anticipatory perspectives themselves subject to governance? In this discussion, I provide a thorough reflection on such governance *of* anticipation in the context of MedTech governance, and I invite HTA agencies to engage with a similarly critical-reflexive stance.

Methodological reflections

In this section, I will reflect on my methodological strengths and limitations. Chapters 1-5 already include a reflection on the strengths and limitations of each study included in this dissertation. In addition, Chapter 6 provides a thorough examination

of T/I research, based on comparative autoethnography. Here I will reflect on several elements of my personal methodological journey. I argue that the main strength of this dissertation is that a practice-based approach to MedTech governance can be a useful method. This approach facilitated my navigation across disciplines and allowed me to examine the topic from multiple perspectives. It served as a complement to more dominant, positivistic approaches to MedTech governance, particularly in demonstrating how multiple goals, objectives, and expectations coexist for the anticipatory practices employed (such as horizon scanning or HTA methodologies), and how contradictions embodied in broader frameworks and paradigm shifts play out at the local level. MedTech innovations are often not yet physical objects in the anticipatory practices I studied but rather existed in the minds of public and private governance actors, their absence fostering multiple interpretations that could be studied through the adopted ethnographic approach. Understanding the emergence, interaction, and conflict between different visions of the future seems a valuable endeavor in light of large scale uncertainties facing MedTech governance today, including but not limited to AI, climate change, and pandemic preparedness.

This practice-based approach was facilitated by my being part of the AWVZ academic collaboration, as well as my participation in the Medical Delta program. This gave me a rather unprecedented opportunity to be present in the networks and spaces of MedTech governance where the early stages of 'futureproofing' are taking place. Furthermore, the duration of my research, which spanned over four years, facilitated the development of relationships with various actors involved in the 'polycentric regime' of MedTech governance (Black, 2008). As I demonstrate throughout this dissertation, expectations, hopes and other ways of meaning-making are a critical component of anticipatory governance of MedTech. My proximity to the actors and places where meaning-making occurs thus facilitated the uncovering of different dimensions of meaning-making, such as path dependencies, the importance of trust, or circumvention of anticipated futures.

However, particularly for my being part of the AWVZ, this integration into the subject environment also required a careful crafting of some level of distance. I created distance in several ways. First, through the institutional agreements with ZIN in the context of the AWVZ, which stipulate academic freedom. Second, the theoretical framework of anticipatory governance and boundary work situated my findings beyond the everyday level of the data collected. Furthermore, discussions with researchers within my supervisory team, as well as with scholars within and outside my research institute, similarly allowed me to develop a more distanced perspective on the topic. Although my supervisory team changed over time, it always included at least one person from

outside ZIN. Finally, I reflected and distanced myself from the data by discussing academic papers at several academic conferences from different research fields, including HTA, public administration and STS.

Furthermore, although the practice-based approach proved useful, I would also like to reflect on some of the discomfort I sometimes experienced, particularly in relation to how a deep, time-consuming and highly reflexive method fits with the more technocratic nature of my study context. The impact of qualitative, especially interpretive-constructivist research is often "multiple, indirect, and subtle" (Van de Sande, 2023, p. 155). I always took great care in sharing my findings with my participants, both as a form of member checking as well as a way of giving back to those individuals that had welcomed me in their worlds. However, my more abstract, generalized and theoretical findings were not always easy to directly translate into practice, and sometimes even clashed with dominant beliefs. Moreover, many of the insights in this discussion section emerged only when I became more removed from such spaces, both physically and temporarily. Many perspectives exist on the relation between science and practice, and I do not strive to provide a conclusive answer to what impact could or should look like. I do however wish to encourage future researchers who are undertaking a similar approach to be aware of potential discomfort, and to not be too tempted to deliver impact in the short term. Telling researchers situated within a scientific system and a governance framework that is generally characterized by myopia and desires for efficiency to 'take their time' is perhaps redundant, but I will still encourage researchers to see where a sense of urgency about the future is shaping their desired actions for the present.

A specific methodological complexity was added by my focus on anticipatory practices, which are often aspirational in nature. My findings, which include a degree of criticism of current practices, can be dismissed with the expectation that anticipatory practices may have problems *now,* but will be worked out in the future. For example, concerning the mismatch between theory and practice in HTA that I observed in relation to the updated HTA definition (Michels et al., 2025; O'Rourke et al., 2020), the insights may be dismissed on the argument that frictions will be resolved over time. While this may be true, I argue that it remains important to study governance mechanisms and technologies that are "not yet" fully present, which Carboni (2024) aptly termed 'having ontologies of partial absence'. As I show, and as Carboni similarly argues, in their experimental nature such anticipatory practices and technologies still produce tangible changes in the world now and in the world that is yet to come, and therefore practice-based research can (and should) "make tangible the ways in which [...] futures are being rethought now"(p.160).

Finally, I would like to reflect on the implications of my study context, focusing mainly on the Dutch and European MedTech governance framework. I would argue that the Netherlands is an efficiency-driven healthcare system with a highly fragmented system, which many interviewees identified as a particular challenge. In practice, this meant that there were many options to study anticipatory practices that fit with anticipatory governance approaches 1 and 2. Of course, because practice-based methods generally emphasize depth rather than generalizability, my findings may differ from other geographical contexts. Although the research shows similarities with findings from studies in other contexts as well as with studies adopting a higher-level approach covering multiple countries (Bloemen & Oortwijn, 2024; Craven et al., 2012; Neale & May, 2020), they should always be interpreted with the predominantly Dutch and overall Western context of my research context in mind.

Conclusion and final remarks

This dissertation explored the policy practices and discourses of 'futureproofing' MedTech governance, through an emerging conceptual lens of anticipatory governance and boundary work. The findings are timely in a period marked by multiple, co-existing crises that seem to create a sense of urgency to more explicitly engage with the future, in rather specific ways. Specifically for MedTech innovations, they are positioned as something that could cause as well as called upon to solve the pressing problems of tomorrow, such as the sustainability of publicly funded healthcare or workforce shortage (Carboni et al., 2022; Gupta, 2022; Hordijk, 2021; Krishnan et al., 2023). That is why governing actors, including HTA agencies, try to proactively ward off those innovations that are expected to have a negative impact and accelerate those that are expected to have a positive impact on (anticipated) issues, through so-called 'anticipatory practices'. Those anticipatory practices often involve inter-, multi-, and transdisciplinary collaboration to map 'unknown unknowns' - unforeseen consequences that only emerge when different perspectives intersect (Renn, 2021; Rinaldi, 2023).

Often, when a sense of urgency to act now is created, governance actors use the tools they have now (Macnaghten et al., 2005). However, the tools that seem to be available for the governance of MedTech, such as HTA and horizon scanning, do not always seem 'fit for purpose' (Mathews et al., 2022). To that end, many of the discussions I witnessed were therefore about broadening the *toolbox* of MedTech governance. Different perspectives existed on the extent to which such tools can be broadened, and this required new ways of working together between the public and private governance actors involved. It seemed, however, that broadening methods, definitions and collaborations is not enough. My studies show that issues are not only about the tools (or methods) of MedTech governance, but much more about different ways of seeing the future and handling uncertainties; the methodologies behind such tools and methods. I therefore identified a need for actors involved in anticipatory practices of MedTech governance to become more reflexive about the relevance and performativity of anticipation in MedTech governance, the assumptions behind it, and the implications for actions needed in the present. Governance actors need to zoom out and ask themselves: What kind of future(s) do we wish to shape?

This is complex in light of the tension at the heart of European (and broader) policy developments: on the one hand, there is a call for accelerating innovation to address urgent needs and to increase competitiveness (EC, 2024; IHI, 2024), whilst on the other, the studies I reference in this dissertation reflect increasing calls to first understand the broader and more long-term societal, ethical, and clinical implications of (medical) technologies *before* they become deeply embedded in practice. I would like to position my findings then as a counter-voice against more widespread calls for urgency. Often,

a sense of urgency carries a connotation to speed matters up: The future is now. Anticipatory practices are then employed as a way of knowing more, sooner, together. However, it seems that pushing for structured processes in a timely manner is often not feasible in the context of MedTech governance. A focus on urgence and timeliness can bury deeper issues. I argue instead for the value of slowing down, of creating space to pause and reflect before implicit assumptions become embedded in the MedTech innovations and MedTech policies.

I have argued how reflexive space is important here, for anticipatory practices to explicitly provide a space for practicing and deliberating on future visions. This means shifting along the x-axis of the anticipatory governance framework as portrayed in figure 1 in the introduction, incorporating more anticipatory practices in line with approach 3 and 4, which aim towards imaginative, inclusive, and critically reflexive engagements with possible futures. Importantly, such a shift also calls for a different way of acting—by both HTA agencies and industry. Rather than casting "boogeymen" or defending from foxholes, it is more productive to recognize that these actors are intertwined and operating within systems that often privilege efficiency over reflection and integration. As my studies show, MedTech governance is ultimately carried out between different actors with different interpretations of and emotional investments in what constitutes good governance. These actors need to build trust to work together across boundaries.

The studies I have conducted also reveal just how complex and layered this task is. There is no quick fix, no blueprint that can be universally applied. I offer the concepts introduced in this dissertation as a useful starting point for such deliberations on which futures we want to make, together, including reflection on dominant framings of the future and their path dependencies; micro-regimes of anticipation; the (reverse) pacing problem; the anticipatory loop; institutional role ambiguities; boundary work; and the collaboration hybrids. Importantly, scaffolding such reflection is not a technical or procedural matter; they are normative and political acts that can help steer MedTech innovation toward futures that are not only efficient or profitable, but also just, inclusive, and socially desirable. It is my hope that the findings of this dissertation will serve to stimulate such debate, and I look forward to discussing these findings with others.

Summary | Samenvatting

Summary

This dissertation explores the governance of innovative medical technologies (MedTech), analyzing so-called anticipatory practices through the theoretical lens of anticipatory governance and boundary work. In the introduction, an overview of the MedTech governance framework is given, as well as an introduction of the research setting, namely *Zorginstituut Nederland*, and an explanation of the interparadigmatic research approach. In response to current challenges with the MedTech governance framework, there are increasing calls for collaborative anticipatory practices to futureproof MedTech governance. This dissertation explores these anticipatory practices, guided by the research question: **How are anticipatory practices shaped by and shaping the governance of MedTech?**

Chapter 1 is a prelude to the MedTech focused chapters of this dissertation. It evaluates larotrectinib as a tumour-agnostic therapy for patients with TRK-fusion-positive cancers, highlighting its cost-effectiveness. The paper demonstrates that larotrectinib provides an incremental cost-effectiveness ratio (ICER) of €41,424/QALY, which is well below the Netherlands' threshold of €80,000 for diseases with a high burden of disease (HBD). This makes the treatment cost-effective, supported by probabilistic sensitivity analysis showing 88% likelihood at the €80k threshold. The paper highlights challenges with applying the standardized HTA framework. Challenges include uncertainty due to heterogeneous patient populations and multiple assumptions across tumour localizations and limited data on post-progression survival, leading to reliance on previous trials (EMA, 2019). The paper underscores how these incompatibilities now require pragmatic approaches and urges HTA agencies to address such incompatibilities.

Chapter 2 is a discourse analysis on the role of European Health Technology Assessment (HTA) agencies in guiding medical technology governance. The study identifies five distinct academic discourses, each framing HTA differently: Discourse 1 emphasizes HTAs as independent evaluators of evidence, prioritizing rigorous, transparent, and efficient processes. Discourse 2 positions HTAs as evidence stimulators, pushing for better, more mature evidence generation. Discourse 3 frames HTAs as conveners bridging stakeholders, advocating flexible and experimental approaches. Discourse 4 critiques HTA agencies for their level of normative reflection, questioning whether HTA agencies' value-laden roles align with broader public needs. Discourse 5 highlights the need for nuanced clinical expertise, arguing that HTA agencies must balance evidence-driven decisions with stakeholder engagement. These discourses highlight the complexity of MedTech governance. While Discourse 1 and 2 focus on technical rigor, Discourse 3, 4 and 5 prioritize stakeholder collaboration and reflection. The study underscores

how conflicting narratives shape policy outcomes, with recommendations for further research into HTA's role in balancing evidence-based decisions with systemic change.

Chapter 3 examines how international horizon scanning (HS) tools address challenges in the governance of emerging MedTech. Key findings reveal four micro-regimes of anticipation shaped by participants' expectations, which coexist with tensions between political and strategic priorities. These include the HTA micro-regime—prioritizing evidence-based HTA and regulatory frameworks, the Facilitation micro-regime—involving regional stakeholders to support procurement and decentralized decision-making, the Regulation micro-regime—identifying disruptive technologies and setting regulatory pathways, and the Collaboration micro-regime—ensuring global efficiency by pooling resources and knowledge. The analysis underscores that while HTA is dominant, other approaches like facilitation and regulation can complement it, fostering a more nuanced view of futures. It emphasizes the interplay between stakeholders' values and knowledge practices and proposes a more inclusive approach to horizon scanning. This work contributes to the literature by illustrating how global actors navigate uncertainty through structured practices.

Chapter 4 critically examines anticipatory practices (APs) by MedTech industry actors, exploring how they navigate interdependent relationships with public governance actors. Using an AP lens, the study identifies three categories—grasping the anticipated future, undertaking the anticipated future, and collaborating with public governance—to illustrate how industry actors shape MedTech governance through anticipatory practices. The paper argues that such APs are interdependent, with public and private actors both shaping the future through anticipation (the "anticipatory loop"). The authors highlight the need for a balance between uncertainty and structured governance, emphasizing reflexive spaces as tools to foster dialogue and innovation. The study underscores the importance of trust, transparency, and open collaboration in MedTech governance, even amid complexities. The work contributes to literature by demonstrating how APs can both stimulate innovation and risk undercurrents.

Chapter 5 explores how HTA methodologies for MedTech governance are expanded through stakeholder engagement in the Dutch ZonMw HTA Methodology 2021-2024 Program, identifying three collaboration hybrids to integrate diverse perspectives. The study highlights boundary work as a mechanism where expanding actors and factors challenges traditional HTA boundaries. Participants debated interpretations of HTA methodologies, with hybrid models (boundary closure, spanning, blurring) representing different approaches to addressing conflicting values. Conventional HTA prioritizes methods for evidence evaluation, placing multi-stakeholder engagement outside the

process. Participatory HTA integrates processes to weigh perspectives, aligning with boundary spanning. Exploratory HTA focuses on societal issues, emphasizing knowledge generation through dynamic integration. These hybrids reflect tensions between theory and practice, showing how broader participation in MedTech governance reshapes traditional HTA frameworks. The study underscores the complexity of balancing stakeholder involvement with practical efficiency, emphasizing the need for iterative reflection to navigate these challenges. This research contributes to literature on HTA broadening and multi-stakeholder collaboration. It highlights the role of boundary work in shaping HTA methodologies, offering insights into how stakeholders engage with evolving frameworks to ensure relevance across diverse contexts.

Chapter 6 explores the invisible labor of transdisciplinary (T/I) research by examining condensing, staging, and trespassing practices among early-career researchers in healthcare. The study reveals that such work often feels "dirty", undermining both researcher wellbeing and productivity. Trespassing, which involves engaging with spaces that reject certain paradigms, contributes to discomfort, as seen in the vignettes where PhD candidates felt pressured to align their research with dominant discourses. The paper critiques existing frameworks for T/I research that prioritize siloed disciplines over interdisciplinary integration. The findings challenge traditional definitions of transdisciplinarity and suggest that T/I PhDs must embody transdisciplinarity to thrive. By emphasizing the role of spaces in shaping these practices, the study offers actionable insights into balancing efficiency with ethical accountability in academic environments. Ultimately, it calls for reorganizing T/I research to prioritize inclusive, sustainable collaboration over rigid disciplinary hierarchies.

Finally, the discussion summarizes and discusses my findings, methodologies and recommendations. I highlight that in response to urgent societal challenges, governance actors—including HTA agencies—engage in anticipatory practices such as early HTA and horizon scanning to manage uncertainty. However, these tools seem to fall short, as deeper tensions exist around how the future is interpreted and acted upon differently across the actors involved. The research highlights challenges such as dominant framings of the future and their path dependencies; micro-regimes of anticipation; the (reverse) pacing problem; the anticipatory loop; institutional role ambiguities; boundary work; fragmented processes, and a growing influence of private actors in governance gaps. It argues that simply broadening methods is not enough—what's needed are reflexive spaces where stakeholders can critically engage with diverse visions of the future. Introducing concepts including more dominant framings of the future and their path dependencies, micro-regimes of anticipation, the (reverse) pacing problem, the anticipatory loop, institutional role ambiguities, boundary work, and the collabo-

ration hybrids, the discussion calls for a more inclusive, reflective, and just approach to shaping MedTech innovation and policy.

Samenvatting

Dit proefschrift onderzoekt de governance van innovatieve medische technologieën (MedTech) en analyseert zogenaamde anticiperende praktijken vanuit de theoretische lens van *anticipatory governance* en *boundary work*. In de inleiding wordt een overzicht gegeven van het MedTech-bestuurskader, evenals een introductie van de onderzoeksomgeving, namelijk Zorginstituut Nederland, en een uitleg van de interparadigmatische onderzoeksbenadering. Als reactie op de huidige uitdagingen met betrekking tot het MedTech-bestuurskader, klinken er steeds meer oproepen tot gezamenlijke anticiperende praktijken om MedTech-bestuur toekomstbestendig te maken. Dit proefschrift onderzoekt deze anticiperende praktijken aan de hand van de onderzoeksvraag: **Hoe worden anticiperende praktijken gevormd door en beïnvloeden ze tegelijkertijd de governance van MedTech?**

Hoofdstuk 1 vormt een opmaat naar de op MedTech gerichte hoofdstukken van deze dissertatie. Het evalueert larotrectinib als tumor-agnostische therapie voor patiënten met TRK-fusie-positieve kankers, en benadrukt de kosteneffectiviteit. De studie toont aan dat larotrectinib een incrementele kosteneffectiviteitsratio (ICER) van €41.424 per QALY biedt, wat ruim onder de Nederlandse drempel van €80.000 ligt voor ziekten met een hoge ziektelast. Daarmee is de behandeling kosteneffectief, ondersteund door een probabilistische sensitiviteitsanalyse die een waarschijnlijkheid van 88% aangeeft bij de €80k-drempel. Het hoofdstuk belicht de uitdagingen bij het toepassen van het gestandaardiseerde HTA-kader, zoals onzekerheid door heterogene patiëntpopulaties, meerdere aannames over tumorlokalisaties en beperkte data over overleving na progressie, wat leidt tot afhankelijkheid van eerdere klinische studies (EMA, 2019). Er wordt gepleit voor pragmatische benaderingen en wordt HTA-instanties opgeroepen dergelijke incompatibiliteiten aan te pakken.

Hoofdstuk 2 is een discoursanalyse over de rol van Europese HTA-instanties bij de sturing van MedTech-governance. De studie identificeert vijf academische discoursen die elk een andere framing van HTA hanteren: Discours 1 ziet HTA als onafhankelijke evaluator van bewijs, met nadruk op rigoureuze, transparante en efficiënte processen. Discours 2 positioneert HTA als stimulator van bewijsproductie, met focus op rijpere en betere data. Discours 3 beschouwt HTA als bruggenbouwer tussen stakeholders, en pleit voor flexibele en experimentele benaderingen. Discours 4 bekritiseert HTA-instanties vanwege onvoldoende normatieve reflectie en stelt vragen bij de waarde-gedreven rollen van HTA binnen publieke belangen. Discours 5 benadrukt de noodzaak van genuanceerde klinische expertise en stelt dat HTA een balans moet vinden tussen bewijs en betrokkenheid van belanghebbenden. De studie toont de complexiteit van Med-

Tech-governance, waarbij Discours 1 en 2 technisch-inhoudelijk zijn, terwijl Discours 3, 4 en 5 de nadruk leggen op samenwerking en reflectie. Het hoofdstuk benadrukt hoe botsende narratieven beleidsuitkomsten beïnvloeden en doet aanbevelingen voor vervolgonderzoek naar HTA's rol in het balanceren van bewijs met systeemverandering.

Hoofdstuk 3 onderzoekt hoe internationale horizon scanning-instrumenten omgaan met uitdagingen in het bestuur van opkomende MedTech. Belangrijke bevindingen tonen vier micro-regimes van anticipatie, gevormd door verwachtingen van deelnemers, die bestaan naast spanningen tussen politieke en strategische prioriteiten. Deze zijn: het HTA-micro-regime (gericht op bewijsgebaseerde HTA en regelgeving), het Faciliterings-micro-regime (regionale stakeholders betrekken voor inkoop en besluitvorming), het Regulerings-micro-regime (disruptieve technologieën identificeren en reguleringsroutes uitzetten), en het Samenwerkings-micro-regime (globale efficiëntie bevorderen via kennisdeling). De analyse benadrukt dat hoewel HTA dominant is, andere benaderingen zoals facilitering en regulering aanvullend kunnen zijn. Er wordt gepleit voor een inclusievere aanpak van horizon scanning. De studie draagt bij aan literatuur door te illustreren hoe mondiale actoren onzekerheid structureren via anticiperende praktijken.

Hoofdstuk 4 onderzoekt kritisch de anticiperende praktijken (AP's) van MedTech-industrieactoren, en hoe zij navigeren binnen wederzijdse afhankelijkheid met publieke governance-actoren. Door het gebruik van het AP-kader worden drie categorieën geïdentificeerd—het begrijpen van de verwachte toekomst, het uitvoeren van deze toekomst en samenwerking met publieke governance. Deze illustreren hoe industriele actoren het MedTech-bestuur mede vormgeven via anticipatie. De studie stelt dat AP's interdependent zijn, waarbij publieke en private actoren gezamenlijk de toekomst vormgeven (de "anticipatory loop"). Er wordt gepleit voor een balans tussen onzekerheid en gestructureerd bestuur, met nadruk op reflexieve ruimten om dialoog en innovatie te bevorderen. Vertrouwen, transparantie en open samenwerking zijn hierbij cruciaal. De studie toont hoe AP's zowel innovatie kunnen stimuleren als risico's introduceren.

Hoofdstuk 5 onderzoekt hoe HTA-methodologieën voor MedTech-bestuur worden uitgebreid via stakeholderbetrokkenheid in het Nederlandse ZonMw HTA Methodologie 2021–2024 Programma. Er worden drie samenwerking hybriden geïdentificeerd om diverse perspectieven te integreren. Het hoofdstuk toont hoe boundary work traditionele HTA-grenzen uitdaagt. Deelnemers discussieerden over HTA-methodologieën, waarbij hybride modellen (boundary closure, spanning, blurring) verschillende benaderingen representeren om conflicterende waarden aan te pakken. Traditionele HTA focust op evidence-beoordeling, terwijl participatieve HTA belanghebbenden integreert en zich richt op boundary spanning. Exploratieve HTA bekijkt maatschappelijke kwesties, met

nadruk op kennisproductie via dynamische integratie. Deze hybriden tonen spanningen tussen theorie en praktijk, en hoe bredere deelname de HTA-praktijk hervormt. De studie benadrukt het belang van iteratieve reflectie om efficiëntie en betrokkenheid in balans te houden.

Hoofdstuk 6 onderzoekt het onzichtbare werk binnen transdisciplinair onderzoek (T/I) door het analyseren van condensing, staging en trespassing-praktijken onder promovendi in de zorg. De studie laat zien dat dit werk vaak als "vies" wordt ervaren en schadelijk is voor het welzijn en de productiviteit van onderzoekers. Trespassing, dat wil zeggen het betreden van ruimtes die bepaalde paradigma's afwijzen, veroorzaakt ongemak, zoals blijkt uit vignetten waarin promovendi zich onder druk gezet voelden om zich aan te passen aan dominante discoursen. De studie bekritiseert bestaande T/I-kaders die vakdisciplines prioriteren boven integratie. Er wordt gesteld dat promovendi T/I-onderzoek moeten 'belichamen' om succesvol te zijn. Door de nadruk te leggen op de rol van ruimten bij het vormen van deze praktijken, biedt de studie concrete handvatten voor het balanceren van efficiëntie en ethische verantwoordelijkheid in de academische context.

Tot slot bespreekt het discussie hoofdstuk de bevindingen, gebruikte methodologieën en aanbevelingen. De dissertatie benadrukt dat governance-actoren, met name HTA-instanties, anticiperende praktijken zoals vroege HTA en horizon scanning inzetten om onzekerheid te beheersen. Deze instrumenten schieten echter vaak tekort, omdat er diepere spanningen lijken te bestaan in hoe de toekomst wordt geïnterpreteerd en benaderd door verschillende actoren. De studie wijst op uitdagingen zoals dominante toekomstbeelden en hun padafhankelijkheden, micro-regimes van anticipatie, het (omgekeerde) *pacing* probleem, de *anticipatory loop*, institutionele rolonduidelijkheden, gefragmenteerde processen, en een groeiende invloed van private actoren in governance-leemtes. Er wordt betoogd dat het simpelweg verbreden van methodes niet voldoende is; er is meer reflexiviteit nodig waar stakeholders kritisch met uiteenlopende toekomstvisies kunnen omgaan. Door concepten te introduceren zoals dominante toekomstbeelden en hun path-dependencies, micro-regimes van anticipatie, het (omgekeerde) pacing-probleem, de anticipatory loop, institutionele ambiguïteit, grenswerk, en samenwerkingshybriden, pleit de dissertatie voor een inclusieve, reflectieve en rechtvaardige benadering van MedTech-innovatie en beleid.

PhD Portfolio

Courses Netherlands Institute of Governance (NIG)

- Collaborative governance for public value, innovation and the role of leadership (2021)
- Getting it published (2021)
- Responsibility and Integrity in research and advice (2021)
- Formulating and answering research questions (2022)
- Making science on politics and governance matter: Strategies for 'bridging the gap' between knowledge and policy (2022)
- Critical and interpretive public administration (2022)
- NIG research day (2022)
- NIG writing week (2023)

Courses Erasmus Graduate School of Social Sciences and Humanities

- Basic didactics (2021)
- Group dynamics (2021)
- Searching and managing your literature (2021)
- Brush up your research design (2021)
- English academic writing for PhD candidate (2023)
- Science meets entrepreneurship (2023)
- Communicating your research: lessons from Bitescience (2023)
- Career Swifters program (2024)

Publications as part of this dissertation

1. Michels RE, Arteaga CH, Peters ML, Kapiteijn E, Van Herpen CML, Krol M. (2022). Economic Evaluation of a Tumour-Agnostic Therapy: Dutch Economic Value of Larotrectinib in TRK Fusion-Positive Cancers. Appl Health Econ Health Policy. Sep;20(5):717-729. doi: 10.1007/s40258-022-00740-1
2. Michels, R., de Graaff, B., Abrishami Shirazi, P., & Delnoij, D. (2024). Anticipating emerging medical technologies: The start of an international horizon scanning tool for medical devices. *Futures, 156*, Article 103326, doi: 10.1016/j.futures.2024.103326
3. Michels, R. E., Delnoij, D. M. J., & de Graaff, M. B. (2025). HTA between theory and practice: Exploring boundary work in broadening HTA For MedTech governance. *Health Policy and Technology, 14*(3), Article 101008. https://doi.org/10.1016/j.hlpt.2025.101008
4. Michels, R., Delnoij, D., & de Graaff, B. (2025). In a Loop of Anticipation: The Anticipatory Practices of MedTech Industry Actors. *Futures*, *171*, Article 103629. Advance online publication. https://doi.org/10.1016/j.futures.2025.103629

Conferences, symposiums and seminars

- ESHPM/EUR research seminars, Rotterdam (2020-2023)
- Medical Delta symposium, MedTech solutions for a healthier tomorrow (2021)
- Technical innovations in Medicine Congress (2021)
- Medical Delta symposium, Leiden (2022)
- EGPA Symposium for Doctoral Students and Junior Researchers (2022)
- Science, Education & Innovation Festival | Sustain the future of healthcare (2022)
- Innovation for Health symposium, Amsterdam (2022)
- Medical Delta Brilliant failures seminar, Delft (2022)
- EASST. Politics of Technoscientific Futures (2022)
- HTAi. Lifecycle Approach: Coming Together to Make It Happen (2022)
- NIG. The Drama of Democracy: Rethinking the Rule of Law in Public Governance (2022)
- ISPOR. HEOR at the Nexus of Policy and Science (2023)
- EU-SPRI. Governing Technology, Research, and Innovation for Better Worlds (2024)
- EASST4S. Making and doing transformations (2024)
- Medical Delta symposium, Rotterdam (2023)
- Health & Technology Disrupt and Deliver (2024)
- MedTech Nederland Samenwerking tussen verschillende partijen in de Zorg – Logisch toch (2024)
- Zorginstituut Wetenschapsdag (2024)

Presentations at conferences

- EASST. Presentation as part of panel on The future of vaccine techno-politics: outcomes and lessons of the covid-19 pandemic (2022)
- HTAi: Presentation as part of panel on Adopting a lifecycle approach in hta: consequences for priority setting and international collaboration (2022)
- NIG: Presentation as part of panel on Robust and time-sensitive governance (2022)
- ISPOR: Two poster presentations as part of MedTech Policy theme (2023)
- EU-SPRI. Presentation as part of panel on Anticipatory practices at the intersection of Innovation, policy and science (2024)
- EASST4S. Presentation as part of panel on Anticipatory governance and presentation as part of panel on Transdisciplinary research (2024)

Presentations for policymakers

- Werkplaatsmiddag Zorginstituut (2021)
- Werkplaatsmiddag Zorginstituut (2022)
- Werkplaatsmiddag Passende zorg Zorginstituut (2023)

- Presentatie ZonMw lunch sessie (2024)
- Presentatie Raad van Bestuur Zorginstituut (2025)

Supervision and teaching activities

- Tutor in the bachelor course Choices and dilemmas (2020-2021, 2021-2022, 2022-2023, and 2023-2024)
- Tutor in the bachelor course Data Driven Dreams (2020-2021)
- Tutor in the master course Quality and Safety (2021-2022 and 2022-2023)
- Master thesis supervisor Law (2020-2021)
- Bachelor thesis supervisor (2023-2024)

Organization

- ESHPM day workshop – Academische Werkplaats (2022)
- Mixed Methods Anonymous presentation at Health Care Governance Group ESHPM (2025)
- Mixed Methods Anonymous presentation at Wageningen University (2025)

About the author

Renée Else Michels is a researcher specializing in healthcare innovation policy. She holds a background in medical anthropology, sociology, health economics, and health policy analysis, reflecting a transdisciplinary and interparadigmatic research philosophy. She completed her PhD at the Health Care Governance Group within the Erasmus School of Health Policy & Management at Erasmus University Rotterdam, where her research was on the governance of medical technologies—particularly focusing on anticipatory practices and boundary work. Currently, Renée works at the Rathenau Instituut, where she continues to investigate how governance of emerging technologies can support health systems in ways that are socially responsible and aligned with the public interest. Renée works to bridge academic disciplines and policy domains, aiming to understand and help shape governance frameworks that guide healthcare innovation for the public good.

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