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Assembling THE surveillance system:

Problematization of global health assemblages in the case of the Global Antimicrobial Resistance and Use Surveillance System (GLASS)

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Neringa Simkute, MA

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Table of Contents

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1. Introduction

In 1945, one of the winners of the Nobel prize for the discovery of penicillin, Sir Alexander Fleming, in his acceptance speech warned about the possible effects of the misuse of antibiotics:

> "*The time may come when penicillin can be bought by anyone in the shops. Then there is the danger that the ignorant man may easily underdose himself and by exposing his microbes to non-lethal quantities of the drug make them resistant*" (Fleming, 1945).

Eighty years onward, the World Health Assembly agreed on the release of the Global action plan on antimicrobial resistance (World Health Organization, 2015). This Global Action Plan on AMR was highly inspired by the UK's chief medical officer at the time Dame Sally Davies who, in 2013, framed antimicrobial resistance (AMR) as "a threat to human health as climate change, that we are now in a fifth era of attention to what has been increasingly described as the global problem of antibiotic resistance" (Podolsky, 2018, p. 2). The WHO continued with the discourse of AMR as an "apocalyptic" global health threat, where a "post-antibiotic era—in which common infections and minor injuries can kill—far from being an apocalyptic fantasy, is instead a very real possibility for the 21st century" (World Health Organization, 2014, p. IX).

To tackle such a global health threat, the Global Action Plan on Antimicrobial Resistance (GAP on AMR) agreed upon by the World Health Assembly in 2015 outlined five key objectives to address AMR on a global scale. Its second objective was dedicated "to strengthen the knowledge and evidence base through surveillance and research" (World Health Organization, 2015a). Corresponding to this objective, World Health Organization (WHO) established the Global Antimicrobial Resistance and Use Surveillance System (GLASS) in October 2015. The overarching goal of the GLASS is to "continue filling knowledge gaps, to inform strategies at all levels" (World Health Organization, 2022a) concerning AMR and its response on a national, regional, or global level. To achieve this goal, GLASS advocates and supports the standardisation of the global collection, analysis and sharing of AMR data. The WHO envisions that the GLASS "provides a standardized approach to the collection, analysis and sharing of national AMR data in samples collected routinely for clinical purposes for a set of pathogens that cause common bacterial infections in humans" (World Health Organization, 2022a). Therefore, the AMR data collected via national or regional surveillance systems and standardised by the GLASS are aimed to form the knowledge for evidence-based policymaking and strategies to prepare to combat the monitored threat through the global standardisation of AMR systems.

However, such an ambitious goal of a global AMR surveillance system is faced with numerous challenges. One of the latest GLASS yearly reports (World Health Organization, 2021a) shows that less than half of the WHO member states submit their AMR data to the GLASS, despite that GLASS was active for five years already at the time of the AMR data collection and sharing reported in the

document. One such challenge is that many regions perceived as lower income do not possess the healthcare and laboratory infrastructures and resources required for AMR data collection and reporting. However, despite having infrastructures in place, some of the countries that are perceived as high-income, still do not share their AMR data with the WHO and GLASS. Therefore, the global surveillance of the GLASS depends on the national countries' political willingness and motivation to build and/or maintain such infrastructures (World Health Organization, 2021a) as well as submit their AMR data to the GLASS platform yearly. Despite these challenges, the currently existing literature on AMR and its surveillance often explores (global) AMR surveillance system(s) while focusing on their limitations (e.g., Schnall, Rajkhowa, Ikuta et al, 2019), gaps between the global (GLASS) and national AMR surveillance systems' methodologies, for example, in Japan (Kajihara, Yahara, Stelling et al, 2020) or an overview of AMR surveillance system(s) and their achievements, needs, or potential solutions of how surveillance could be improved (Mogasale, Saldanha, Pai & et al, 2021; Graells, Heizel & Jorgensen, 2020). However, the currently existing literature, particularly in the Science and Technology Studies (STS) field, does not appear to look yet in detail at how the global AMR surveillance system, such as GLASS, is assembled and constructed through a variety of practices as "global" as well as where the tensions and resistances occur that challenge the GLASS assemblage as a global AMR surveillance system.

In the case of GLASS, the assemblage of "global" is challenging as the WHO is assembling GLASS not only from the top to bottom, such as imposing its methodology to other countries but also working from the bottom-up on the pre-existing surveillance systems on national and regional levels, where the AMR surveillance harmonisation is envisioned. The WHO assembles GLASS via standardisation efforts, including the decisions about what AMR data should be collected, where, and how. These efforts include the WHO´s endeavours to navigate complex power relations between different stakeholders in the global health field as well as different expertise and knowledge of how the GLASS should be assembled as a global surveillance system. The standardisation practices of the GLASS-enabled surveillance allow seeing what is visible and prioritised in a global assemblage, for instance, which stakeholders, expertise, and data collection practices. Similarly, the standardisation practices of the WHO also allow exploring further what is left out of the global assemblage of the GLASS, for instance, what stakeholders, expertise, or data collection practices, as well as other resistances. Therefore, in this thesis, I aim to answer the research question:

How does the WHO assembles the "global" in global health through its knowledge practices and embedded power relations in the global health field while implementing the Global Antimicrobial Resistance and Use Surveillance System (GLASS)?

I have arrived at and refined this research question through the initial literature review as well as the review of the GLASS documents and initial interviews. Following the understanding of global health assemblage (e.g., Collier, 2006) this thesis intends to explore and point out what is made visible and

prioritized in the global health field while assembling global solutions to global threats, such as AMR, as well as what challenges, complexities, and resistances are left out of the publicly accessible discourses. Therefore, this question matters as it can show what expertise and knowledge are more acceptable and prominent in practices and solutions that are perceived as "global" as well as which rationale they use to convince others of their "global" visions. Zooming into the global health field, this question also shows how global threats, such as AMR, are rationalised as well as what solutions are perceived as "global".

Although the topics in this thesis mainly revolve around the assemblages in the global health field, including surveillance and AMR, it could also be beneficial to broader audiences from the fields of Science and Technology Studies (STS) and social sciences. On one hand, this thesis shows the complications of how we understand, govern, and assemble the "global" and global solutions as well as the underlying tensions and resistances in such endeavours. However, this work not only explores how we assemble solutions and deal with infectious disease threats in the global health field, such as AMR but it can also show how we understand and prepare for global challenges outside of the global health field. This thesis highlights the complex interactions, tensions, and understandings between the global and the national or local, different experts, stakeholders, the ways of knowing, and relations between the Global North and Global South. The exploration of these themes in this thesis could be helpful in other fields as well, particularly in understanding how the "global" solutions are assembled and governed.

To answer my research question, GLASS serves as an insightful case as it is called and carved out to be a "global" surveillance system. AMR is currently receiving increased attention in the global health field, therefore, strategies to tackle it, such as GLASS, are currently more visible. As GLASS is still being currently assembled, it is more visible in the publicly available sources what knowledge practices and expertise are involved in GLASS assemblage as well as how they are rationalised and supported. Although GLASS mostly addresses tackling AMR and involved actors in the global health field, looking at the case of the GLASS assemblage can also apply to the exploration of other (health) threats that are perceived "global" as well as how their solutions are envisioned and assembled, including the knowledge practices and navigating the embedded power relations in the global health field.

To answer my research question, I refer to WHO´s knowledge practices and its navigation of embedded power relations in the global health field. In the case of knowledge practices, I explore the expertise involved in the GLASS assemblage, such as epidemiology, laboratory practices, clinical work, as well as data collection, sharing, and analysis practices. Next to these practices, the WHO works in a complex global health field that includes other international organizations and initiatives that work on AMR; countries and regions that are often classified as lower or higher income, among other actors. Therefore, with the embedded power relations in the global health field, I refer to the WHO´s relations to other global (e.g. other international organizations, high-political level figures, countries, public-private

partnerships) and more local level actors (e.g. laboratories, clinical sites, public health bodies, funders) while assembling and rationalising GLASS. To answer this thesis question methodologically, I have qualitatively analysed many publicly available WHO documents on the GLASS (its yearly update reports, methodological papers, and meeting reports) as well as conducted four qualitative expert interviews with persons who are involved in AMR surveillance on national and/or regional levels and who are also familiar with the GLASS activities.

Overall, the WHO´s visions for global AMR data collection mainly include aspects that AMR data should come from laboratories, include additional epidemiological information about patients, be representative, represent One Health paradigm (including AMR in animals and environment), and come equally from both envisioned higher- and lower-income regions. However, GLASS is shaped by different interests within and outside of the WHO as well as different interests and understandings about AMR. On the one hand, GLASS aims to map AMR spread globally which is perceived as a global health threat as well as close knowledge gaps in the regions where such mapping has not been carried out before to create knowledge that could help to mitigate AMR. On the other hand, GLASS activities fall under the global health security regime (Lakoff, 2017), where the fear by the "global North" of cross-border infections leads to the need for the "global South" to build up infrastructures and comply with AMR data collection standards. Therefore, GLASS standardisation efforts (Timmermans & Epstein, 2010) of AMR surveillance globally are complicated because there are different interests and different priorities caught in different meanings of "global health" and AMR. Such high-level political standardisation and concerns about health security and knowledge gap do not leave space for the local concerns and capabilities, such as the lack of healthcare and laboratory infrastructures; additional and unpaid data labour required from healthcare staff to collect epidemiologically representative AMR data; overlapping issues and more complex capabilities of countries than the simplification of higher and lower-income regions; and prioritization of human health instead of conducting One Health surveillance as well as prioritization of resistant bacteria over other resistant organisms, such as fungi. To this end, this thesis enables us to see how global health initiatives, such as GLASS, are assembled in the global health field, what is prioritised, and what remains less visible.

Overall, I have selected to explore the topics of antimicrobial resistance surveillance and global health following my previous work experiences and experiences as a Master's student in the Science-Technology-Society (STS) programme at the University of Vienna. I first encountered the topic of AMR in my previous work experiences while working on public policy analysis projects. There, I familiarised myself with AMR as a global health threat and particularly with one of the strategies for research, development, and innovation which has foreseen more efficient and faster development of antibiotics. Such strategies were also mainly supported by the data collection efforts to understand where the different funders or national countries invest and how to achieve increased "global" synergies for antimicrobial research and development. However, my experiences in the STS programme expanded

my understanding of the AMR topic. Particularly the course “STS perspectives on global health crises - Epistemologies, economies and ethics of vulnerability and (in)security” by Dr Christian Haddad and the concepts used in the course, such as the explorations of the global health understandings (e.g., McInnes, 2016) global health security regime (Lakoff, 2017), epidemiological thought style (e.g. Reubi, 2018), among others, expanded my understanding of AMR and its global surveillance as well as the underlying power practices and knowledge practices in the global health field. These concepts as well as other STS courses and discussions greatly inspired and informed this thesis.

The following parts of the thesis are structured as follows: Section 2. State of the Art, where I provide an overview of existing literature on the topics of understandings about global and local, global health, the emergence of antimicrobial resistance as a global health threat, the surveillance practices in the global health field as well as the AMR surveillance as one of the solutions for the global threat of AMR. In Section 3. Assembling a case study, I overview the main research question, including the facilitating sub-questions, and present the case study of GLASS as well as materials and methods used, namely documents and expert interviews, their analysis, and the encountered limitations. In Section 4. Theoretical Perspectives, I explore the understandings used for this thesis, such as the global assemblage (Collier, 2006), global health security regime (Lakoff, 2017) and standardisation (Timmermans & Epstein, 2010), In Section 5. Empirical analysis, I present the main observations from my material analysis following the research question presented in the previous section. In Section 6. Discussion, I then explore my empirical findings in line with the existing literature. Finally, in Section 7. Conclusion, I present a brief overview of the main research findings and potential streams for future research.

2. State of the Art

In this section, I explore the existing literature about the emergence of antimicrobial resistance (AMR) as a global health threat as well as surveillance as one of its potential tackling strategies. I then look at the existing literature on the understanding of "global" and the emergence of the global health field as well as the complexities and actors involved in it. Lastly, I review the different modes of counting used in the global health field as well as how they differ within different understandings of global health and what different actors and expertise they involve. Overall, the State-of-the-Art section shows that AMR is framed as a global health issue and explores how the "global" is problematized in the global health field, including the counting practices and their different rationales that are also applied in tackling AMR. This thesis also shows the complexities in the global health field, such as a close entanglement between the global and the local elements in the global health field and the complex relations of actors existing within this field, including the activities of AMR surveillance.

2.1. Emergence of antimicrobial resistance as a global threat and tackling AMR on a global scale

In this section, I review how antimicrobial resistance (AMR) has been addressed on national and global levels since the 1940s as well as the WHO´s involvement in the AMR field. This section also reviews STS's stance on AMR as well as explores the envisioned solutions to AMR, where the visions emerge based on different localities, such as higher-income and lower-income countries and regions. This section then zooms into one of the strategies to tackle AMR that is the key to this thesis – AMR surveillance – and explores the currently existing literature on national and global surveillance systems and capabilities and challenges in surveillance that are mainly perceived to be based on location (such as in the countries and regions perceived to be lower-income). This section also looks into the future visions of AMR surveillance and what stakeholders are envisioned to be involved. Combining these themes, this section focuses on the literature gap that I observed concerning the existing literature towards GLASS as a global assemblage of AMR surveillance.

Since the development of antibiotics, there were already efforts carried out that recognised antimicrobial resistance (AMR) as a threat. However, it took decades for AMR to be shaped as a global health threat. Podolsky (2018) in detail analysed the emergence of AMR as a global threat from the 1940s to the 21st century. Since the development of antibiotics in the 1940s, Sir Alexander Fleming recognised the AMR phenomenon as a threat during his acceptance speech for the Nobel prize. However, there were no efforts to address AMR at that time and only a small number of countries introduced some research actions, such as the United Kingdom in the 1950s exploring Staphylococcus aureus pathogen resistance against antibiotics (Podolsky, 2018, p. 2). Starting with the 1980s, further efforts emerged that aimed to address AMR among several countries.

Podolsky (2018, p. 3) further explores that one of the earlier global responses to address AMR came from the United States, initiated by clinician Stuart Levy from Tufts University. In 1981, Stuart Levy organised a conference that involved participants from 27 countries, with the majority of participants coming from the United States. In this conference, participants signed the "Statement Regarding Worldwide Antibiotic Misuse", where AMR was recognised as a "worldwide public health problem" and potential solutions to address AMR mainly revolved around minimising the antibiotics use globally. However, envisioned global solutions to AMR did not receive sufficient attention at the time, especially in the national countries, where, for example, in the 1980s, the governments of the United States and the United Kingdom reduced their public spending, including in the field of public health (Podolsky, 2018, p. 3). This also led to the prioritisation of some health topics over others and mainly the prioritisation of AMR.

The World Health Organization (WHO) started to actively look at AMR topics starting in the 2000s. In 2001, WHO released the "Global Strategy for Containment of Antimicrobial Resistance" – a document which outlined the effects of AMR as well as its potential economic and national security impacts (World Health Organization, 2001). Here, the AMR and the strategy to contain it was framed as "global" which also coincides with the emerging understanding of "global health" at the end of the 20th-beginning of the 21st century (McInnes & Lee, 2012). Despite the previous efforts to coin AMR as a global threat, Podolsky (2018, p. 2) explores that AMR started to particularly gain global attention in 2013 when the UK's chief medical officer Dame Sally Davies framed it as "a threat to human health as climate change, that we are now in a fifth era of attention to what has been increasingly described as the global problem of antibiotic resistance". Since then, a number of high-level political bodies corresponded to the global AMR threat, for instance, the United Nations, the World Bank, the World Health Assembly, and the WHO released the Global Action Plan on AMR in 2015.

The understanding of AMR as a (global) issue has also been explored by social scientists, including science and technology studies (STS). In the current research, AMR is often seen and explored as an issue caused by antibiotic use and misuse and tied to individual behaviour. For example, Will (2020) analysed the public health campaigns on the overuse of antibiotics in the United Kingdom, where the public was often imagined as ignorant, while this imagination limited the public's political engagement with AMR and has drawn a distinction between the laypersons and experts working with the government on informing AMR response (Will, 2020, p. 23). Meanwhile, others aimed to explore AMR in broader terms, going beyond individual behaviour and human health overall. For instance, Chandler (2019) goes a step further and draws the dichotomy between the understanding of AMR in the One Health paradigm (including human, animal, and environmental health) versus the responsibility of the individual:

> "(…) the paper draws out a contrast between the way AMR is formulated in terms of a problem of connectedness—a 'One Health' issue—and the frequent solutions to AMR

> being focused on individual behaviour. The paper suggests that AMR presents an opportunity to take seriously connections, scale and systems but that this effort is undermined by the prevailing tendency to reduce health issues to matters for individual responsibility" (Chandler, 2019).

The understanding of AMR as an issue caused by individual behaviour of human antibiotic use, instead of technology and infrastructures is also criticised by some of the STS researchers:

> "We can't simply assume beforehand that the problem lies solely with patients not adhering to their drugs! Global Health rhetoric always blames the patients for not going where the technology is; it's a trap to believe that it is never the technology that is at fault" (Sariola, Engel, Kingori, et al, 2017, p. 3).

Therefore, there is a pertaining logic that AMR should be addressed from top to bottom or from the global to the local as the local complexities or publics are the ones that contribute to the AMR threat due to the behaviour of misusing antibiotics. However, some researchers argue that addressing AMR from top to bottom, namely from global to local, could be a difficult task as global relies too much on too complex local conditions. Baekkeskov et al (2020, p. 15) draw from Ostrom (2010) and the "polycentric systems" approach that is suggested to be applied to global environmental change. Ostrom conceptualises global problems, such as climate change, as the "cumulative result of actions taken by individuals, families, small groups, private firms, and local, regional, and national governments" (2010, p. 550). To this end, the author argues:

> "that instead of focusing only on global efforts (which are indeed a necessary part of the long-term solution), it is better to encourage polycentric efforts to reduce the risks associated with the emission of greenhouse gases. Polycentric approaches facilitate achieving benefits at multiple scales as well as experimentation and learning from experience with diverse policies" (Ostrom, 2010, p. 550).

Baekkeskov et al (2020, p. 15) see that a similar approach could be used for AMR as well – instead of having one global approach, it could be beneficial to test and learn about potential solutions in different "centres". Rubin (2019) also refers to the polycentric systems in the case of tackling AMR and draws on the understanding of "glocalization" as "a combination of non-binding and binding agreements at multiple levels and across different sectors" while creating a "more complex global governance regime" and combining global and local governance (2019, p. 2).

However, in the understanding of global health and AMR threat, instead of "centres", there is a common understanding of the "global" division between the "global North" or regions classified as higher-income versus the "global South" or the regions understood as lower-to-middle income. An activist stance presented by Sariola et al (2017, pp. 4-5) points to the issue that countries from the global South

can be excluded from the design of global solutions to the global threats, such as AMR and "centres" as suggested by Ostrom (2010) that could potentially test AMR solutions:

> "the current Global Health intervention designs and products are not relevant to those in the Global South because they fail to understand the local context. Southern partners are excluded from the design process and Northern partners have all the say. As I said before, these are historically-based structural processes that have not changed much from colonial times".

In some of the literature, the AMR health burden is often perceived to be bigger in lower-income regions and distributed unequally on a global scale: "global burden of infectious disease is distributed highly unevenly and low-income countries are disproportionately affected by AMR" (Littmann & Viens, 2015, p. 212). Therefore, some of the research foresees that the higher-income regions should carry an increased responsibility towards funding the medical interventions or surveillance solutions for AMR:

> "This implies that HICs (high-income countries) should bear most of the burden of effective global stewardship of AMR by financing research into new drugs and technologies, as well as by enhancing surveillance and reporting systems" (Baekkeskov et al, 2020, p. 13).

Therefore, distributing the responsibilities between the higher and lower-income regions is seen as crucial to addressing AMR, especially globally, however, the responsibility of distributing these responsibilities is often assigned to the regions assumed to be higher-income or from global North:

> "(HICs) have direct repercussions for the prospect of setting up an effective system of global governance: the distributional consequences (in terms of responsibility, impacts, and costs) might need to be addressed to ensure that many countries take actions against AMR" (Baekkeskov et al 2020, p. 13).

Following these complexities and divisions in the global health field, AMR surveillance is viewed as a response to a global health security issue of AMR threat (Wernli, Jørgensen, Morel, et al, 2017, pp. 4-5; Lakoff, 2017) between "global North" and "global South" as one of the strategies to tackle AMR. The systematic literature reviews of AMR surveillance show that AMR surveillance systems are mainly established and maintained on the national level. Some reviews show that most of the national AMR surveillance systems are based in Europe and European countries (Diallo, Baron, Abat, et al, 2020). The existing AMR surveillance systems in some cases are connected through regional systems, such as the European Antimicrobial Resistance Surveillance Network (EARS-Net) established in 1998 and connecting all the European Union countries, including Norway and Iceland, and their AMR data collection practices (European Centre for Disease Prevention and Control, n.d.). Another regional AMR surveillance system established in 1996 is the Latin American Network for Antimicrobial Resistance Surveillance or ReLAVRA+. The network was established and is running under the WHO and currently

connects 20 national countries from Central and South America as well as the Caribbean. Most of these systems focus on collecting data from human samples, while AMR surveillance in animals and the environment as well as One Health surveillance is still limited, mostly due to the missing infrastructures, technologies, or unclear and inconsistent data collection methodologies. (Baekkeskov et al, 2020, p. 2).

The intention to integrate a variety of AMR surveillance systems into a broader AMR surveillance system succumbs to different limitations that have been persisting for decades now, as shown by the systems that have been established since the 1990s, such as the European and Latin American AMR surveillance networks. For instance, the main challenges for the connected European AMR surveillance system can be categorised as structural (differing objectives, lack of data sharing coordination, standardisation), laboratory-based (insufficient data and biases in collecting samples), and lacking "coordination between human, animal, and food systems" (Tacconelli, Sifakis, Harbarth, 2018, p. 103). Chandler (2019, p. 3) also argues that it is difficult to collect evidence via surveillance on AMR due to the limited AMR counting capacities, lack of unified definitions concerning what AMR is as well as extensive resources required to set up the standardised surveillance systems which are not available in lower-income regions. The methodology of laboratory-based surveillance is also criticised as they use only clinical samples and that is "not likely to be useful as an early warning system for emerging pathogens and resistance mechanisms" (Tacconelli et al, 2018, p. 99), meaning that AMR surveillance based on laboratory data cannot show and warn about the threat fast enough to the envisioned urgent responses.

Despite the common challenges for AMR surveillance as well as implementing global interventions in more local settings, it is still perceived that AMR surveillance is particularly needed and challenging in the countries classified as low-to-middle-income (LMICs). The main challenges are envisioned to be caused by the missing or weak broader infrastructures there, such as the "weak laboratory capacity, poor health systems governance, lack of health information systems, and limited resources" (Iskandar, Molinier, Hallit, et al, 2021). Another challenge relates to the perceived temporality that building such infrastructures will take too much time against such an urgent threat as AMR because "the routine generation of a sustainable flow of reliable data will take time to establish before it can deliver a clinical and public health impact" (Ashley, Shetty, Patel, et al, 2019, p. 541).

One of the potential solutions for such limitations could be alternative solutions or collaborations that do not require established laboratory infrastructures. Once again, such solutions are mainly envisioned to solve the problem of missing data in LMICs and not so much in other regions, although the challenges for laboratory-based AMR testing persist there as well. For instance, some research explores that "there are a large number of pharma- and academia-led initiatives that have generated a wealth of data on AMR and drug-resistant infections in low-resource settings, together with high volume data generation by private laboratories" and that these alternative sources of AMR data could potentially "provide a short-term solution that bridges the gap between now and the time when routine surveillance capacity

will have been established and how this could continue to support surveillance efforts in the future" (Ashley et al, 2019, p. 541). Nevertheless, such research does not elaborate further on what may happen if routine AMR surveillance capacities based on the broader infrastructures of healthcare, laboratories, and similar might not be established in lower-income settings in the future. Such reviews often base their explorations on the baseline that AMR data and surveillance should be conducted in laboratories.

This need for laboratory and other capacities is often based on the visions coming from the global North, where infrastructures needed for the envisioned broader AMR surveillance are already established. The activist stance explored by Sariola et al (2017) criticises such an approach that countries from the "global South" need to catch up regarding AMR solutions and highlight that some countries are being excluded from the design of "global solutions" due to the lack of capacities that are already set by the "Global North" or "Western" countries, such as the funding, access to journals, knowledge, skills, and infrastructures. Meanwhile, STS research questions "why is it always the capacity of those in the Global South that needs strengthening? (…) we should also be talking about strengthening the capacity of the scientists and those in the Global North to appreciate how technologies and drugs work in the real-world" (Sariola et al, 2017, p. 5). However, such questions are still largely invisible in the global health security discourses, including the understanding of AMR as a global threat and its surveillance.

Other antimicrobial resistance surveillance efforts that consider themselves "global" are carried out by platforms outside international organisations, such as WHO's GLASS and national AMR surveillance systems. For example, AMR surveillance efforts are presented by the platforms, such as Pathogen.watch (2018) developed by the Wellcome Trust, University of Oxford, and Centre for Genomic Pathogen Surveillance; or the HealthMap ResistanceOpen (2018) platform established by the HealthMap at Boston Children's Hospital in 2018. For instance, Pathogen.watch provides global pathogen surveillance based on community-driven data where, after registering and signing in, members can upload whole-genome sequencing (WGS) analyses (in a form of datasets or publications). Meanwhile, the platform´s users can obtain AMR predictions for selected pathogens on global/regional/national levels. This platform is already used for research purposes, for example, by Argimón, David, Underwood, et al (2021, p. 325) to conduct a "real-time analysis of Klebsiella genomes to aid surveillance at local, national, and global levels" in low-to-middle income countries, such as Colombia, India, Nigeria, and the Philippines. Another platform, HealthMap ResistanceOpen, is a web-based solution that aggregates "publicly available and user submitted resistance data. It is an open-collaboration database, where independent sources can contribute data" (HealthMap, 2018). Global and standardised AMR surveillance based on GLASS methodology is facing issues of "(1) central processing of isolates, (2) small sample sizes from a limited range of centers, (3) poor geographic resolution, (4) delayed reporting, and/or (5) limited public access to data" (MacFadden, Fisman, Andre, et al., 2016), ResistanceOpen is suggested to support the global surveillance efforts.

Future visions of AMR surveillance globally as well as locally also include the AMR health burden estimations and other visions related to technology development, such as artificial intelligence or big data. Most visibly in the literature, AMR health burden estimations are being carried out by the Institute for Health Metrics and Evaluation (IHME) in the United States with the latest publication by Murray, Ikuta, Sharara et al (2022) "Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis". However, the methodologies of estimating AMR health burden succumb to numerous challenges, such as "difficulties in linking surveillance data with clinical or outcome data and causal attribution" (Ashley et al, 2019, p. 544), meaning that it is difficult to determine whether the health burden can be assigned to AMR, especially if the patient is suffering from other health conditions and diseases. Other future visions of AMR surveillance include the visions of AI and big data as they "could lead to more effective mechanisms of AMR data capture, sharing and analysis tools" (Ashley et al, 2019, p. 544). However, similar to the lack of infrastructures in the regions perceived as low-income and the visions that they will be built and maintained to provide AMR data in the future, the visions for AI and big data are still vague and not currently implemented for AMR surveillance.

Although there is an emerging volume of AMR and its surveillance research, it usually focuses on the limitations of AMR surveillance (e.g., Schnall, Rajkhowa, Ikuta et al, 2019), gaps between the global (GLASS) and national AMR surveillance systems' methodology (e.g. between the GLASS and Japan explored by Kajihara, Yahara, Stelling et al, 2020) or an overview of AMR surveillance system(s), their achievements, or future needs (Mogasale, Saldanha, Pai & et al, 2021; Graells, Heizel & Jorgensen, 2020). Meanwhile, the social science research, including STS, criticises the common understanding of AMR surveillance and its division between the "global North" and "global South". In addition, Rubin (2019, p. 1) observes that "less attention has been paid to the tensions between global and local solutions", especially in the case of tackling AMR. At the time of writing this thesis, I have not been able to locate an analysis from the perspective of the social sciences and STS on the Global Antimicrobial Resistance and Use Surveillance System (GLASS) related to its assemblage and how the WHO uses the knowledge practices and navigates the embedded power relations in the global health field while assembling GLASS as "global". The subsequent chapters in this section further explore how the "global" is problematized in the global health field as well as the surveillance practices and their different rationales that are envisioned to tackle AMR.

2.2. Understandings of global in the global health field

This section presents the literature overview on how is global understood as well as the notion of global health. The section further zooms into the complexities of the understanding of global health which includes the entanglement of global and local as well as the involvement of actors, such as the WHO and their role in the global health field. The section also shows the WHO´s involvement in global health regimes, such as global health security regimes, and the emergence of health and disease surveillance.

The existing social sciences literature explores the understanding of what constitutes global and local, including such understandings in global health. Worthington (1993) explores a "common" understanding that "global" occurrences can be understood as "when most people in most places are affected by them at least some of the time" (p. 178). Worthington distinguishes between the "international" and the "global", considering that the "global" removes the emphasis on the national countries and that the global can surpass the boundaries of the local:

> "(…) the concept of international relations emphasizes intercourse among distinct peoples (nations), whereas the idea of global relations takes the common ground of all people as its frame of reference. Finally, international relations may be quite local in scope, with little significance for a wider social group (e.g., the daily border crossings between Detroit and Windsor), whereas global concerns are by definition not contained by political, social, cultural, regional, or other local boundaries" (1993, p. 178).

However, the understanding of global health shows how the "global", as defined by Worthington (1993) can struggle to surpass local boundaries and even be resisted by political, social, cultural or regional aspects.

The notion of global health builds on the understandings of international health and colonial health (Adams, 2016) and the understanding of "international health". McInnes and Lee (2012, pp. 7-8) explore international health mainly as "health in countries where imperialist powers extended their military and commercial reach", geographical differences between countries and "tropical diseases"; the socioeconomic status and "health status and needs of populations in developing countries", while being used to "refer to comparative analysis of national level health systems and problems". Since the mid-1990s, the understanding of international health shifted towards global health. As McInnes and Lee (2012, p. 8) explain, this shift was caused due to the faster globalization processes, while "the new term offered a political boost to long-neglected public health problems, notably but not exclusively in developing countries", while it also offered a "response to how human health is being affected in new ways by global interconnectedness". To this end, the imaginations of global health encompass health threats, interventions, and challenges beyond the national countries' borders. McGoey, Reiss, and Wahlberg (2011, p. 3) argue that the "global health move has opened up a worldwide epidemiological and demographic problem space within which disease burdens, distributions, movements and causes are mapped out and rendered problematic". To address this "problem space", McInnes (2016) foresees that the global health field adopted certain elements of response:

> "global health narrative had also facilitated an accepted, globally applicable pathway of response to the risk of disease outbreaks based on three elements of surveillance, control (including an epidemiological understanding of the disease) and pharmacological interventions" (p. 387).

However, the understanding of global health is not a straightforward one and can be contested. As argued by Montgomery, Kingori, Sariola et al (2017), from the Science and Technology Studies (STS) point of view, the understanding of global health can be a "messy hybrid" (p. 6), where different entanglements between the global and the local, including the "geographical, political, institutional and sectorial boundaries" (p. 3) intertwine and can even resist each other.

In the global health field, some authors looked more closely into the entanglement between the global and the local, particularly in different disease outbreaks and their management, such as how global health interventions are implemented in local settings. For instance, Kevany, Khumalo-Sakutukwa, Murima et al (2012) looked at how global HIV interventions are implemented and accepted in different local contexts in South Africa, Zimbabwe, Thailand, and Tanzania. The authors' fieldwork observations showed that the successful global interventions in the local contexts and their protocols should avoid "the use of excessively dogmatic or didactic language, be flexible and "designed with the expectations and needs of recipient communities in mind", while the "adaptability to local conditions may help to break down a both behavioral and environmental barriers" (Kevany et al, 2012, p. 10). In the end, the implementation of global HIV intervention projects in the local settings of South Africa, Zimbabwe, Thailand, and Tanzania proved to be successfully implemented and accepted as interventionists worked to understand local communities and their "social, cultural and religious perspective" (2012, p. 10). Therefore, this showcases a success story of how global and local settings corresponded to each other.

However, other global health initiatives can still fail in times of emergency due to various global or local aspects and their clashes, such as the challenges in global or local infrastructures or the local resistance. For instance, during the Ebola outbreak in West Africa in the mid-2010s the "early cases were misdiagnosed, often as Lassa fever (another haemorrhagic fever endemic to the region)" and the outbreak quickly spread in the region due to the weak healthcare infrastructures as well as difficulties in communication between the local healthcare settings and the WHO as well as within the WHO itself (McInnes, 2016, p. 391). Another example of global and local collision is provided by Sivaramakrishnan (2011) who looked into the politics of global-local health while addressing the epidemic of the severe acute respiratory syndrome (SARS) outbreak in Surat, India in the 1990s, at the time was also being referred to as the plague outbreak. In this research, the author does not draw a particular distinction or a boundary between the global and the local but looks at the case as an entanglement:

> "(…) representing the interests, mobility, and interconnectedness of various actors and events as they played out during the outbreak. Both of these terms also represent concerns relating to national sovereignty and security that were central to the evolution and emergence of new ideas and agendas in global health and its governance during the 1990s" (Sivaramakrishnan, 2011, p. 1033).

Therefore, the understandings of global health explored by McInnes (2016) and Sivaramakrishnan (2011) research shows that while the global and local closely influence each other, there are still complexities, clashes, and resistances in their entanglement.

These global and local interactions during the global health crises show that one "global" actor in the global health field emerges in particular. The Surat epidemic in India allowed the WHO "to explore a new global role for itself" (Sivaramakrishnan, 2011, p. 1035), especially because the WHO assumed the role of an interventionist in the epidemic outbreak. At the same time, it experienced different "local" reactions. For instance, in India, the WHO interventions were met with local political resistance, while the WHO´s role was supported by the concerns voiced by other national countries, such as the United States, particularly about the infectious diseases that emerge in Africa or Asia and travel globally:

> "The WHO's concerns regarding reemerging infections and global disease surveillance networks also stemmed from concerns voiced among United States–based agencies such as the CDC and the Institute of Medicine regarding the threat posed by new and reemerging infections to human security and social stability in the new, interconnected geopolitical landscape of global health. These infections, with their epicenters in Asia and Africa, were associated with HIV/AIDS and recent outbreaks such as monkeypox, hemorrhagic fevers, and drug-resistant tuberculosis" (Sivaramakrishnan, 2011, p. 1035).

To this end, the WHO has also been transformed due to the shifting paradigm change of global health. During the period of "international health", the WHO served as the "unquestioned leader of international health" (Brown, Cueto & Fee, 2006, p. 62). In 1948, the WHO was created following the establishment of the United Nations and the World Health Assembly in previous years. With its establishment, the WHO connected several existing health institutions, such as the Office Internationale d´Hygiene Publique, the League of Nations Health Organization, and the United Nations Relief and Rehabilitation Administration (UNRRA). The first activities of the WHO concentrated on the exchange of epidemiological information as well as "administration of international sanitary agreements (Brown et al, 2006, p. 64). However, in the 1980s and 1990s, with the onset of "global health", the WHO found itself in a middle of fierce criticism, including the controversies of director general of the WHO, including the corruption and poor management; "extrabudgetary funding" that shifted attention away from the countries and regions that could not contribute as much towards the satisfaction of bigger beneficiaries, and other competing organizations that worked on similar health topics, such as the World Bank, that also was perceived as more effective. To this end, with the beginning of the understanding of global health, the WHO "began to refashion itself as the coordinator, strategic planner, and leader of global health initiatives as a strategy of survival in response to this transformed international political context" (Brown et al, 2006, p. 62). The emergence of other multiple actors, such as international bodies, funders, countries, high-level political actors, and public-private partnerships shows that the

WHO started to work and implement its work agenda, including health initiatives, in a much more complex global health field.

Overall, this section shows the complexities in the global health field, such as a close entanglement between the global and the local elements of the global health field as well as the multiplicity and the complex relations of actors, such as the WHO and national countries and their public health agencies, existing within this field. The section below further explores the understanding and emergence of disease surveillance within the global health framework as one of the strategies used to monitor and address threats and diseases perceived as global health threats.

2.3. The multiple understandings of counting within the global health field

This section presents the multiple meanings and rationales of counting within the global health field, such as decision-making based on evidence, datafication, and surveillance. This section also shows how these different ways of counting are embedded into differing understandings of global health regimes (Lakoff, 2017).

The existing body of literature explores the counting strategies for a variety of global as well as more localised needs to support public management based on evidence. Counting and surveillance first started on a local or national level and then gradually expanded to global efforts. As Miller (2005) explores, throughout the 19th to 20th centuries data collection, aggregation and use formed the basis for public management decisions following the expansion of technological capabilities as well as researchers trained in these methods:

> "expert bureaucracies became sites for the collection, aggregation, and publication of increasingly larger and larger databases of statistical information, and the applied social scientific disciplines became training grounds for both the elite researchers who analyze statistics and the uncounted bureaucratic officials who translate them into public management decisions" (p. 406).

To this end, data collection, statistical analysis and its use spread among the countries. Counting and data collection, especially for public management purposes, was particularly common in the United States. As Miller (2005, p. 407) tells, following the Second World War:

> "Americans not only thoroughly quantified public policy and administration but also became the most important driving force behind efforts to export quantitative tools of public management to developing countries (especially in areas such as government accounting and policy analysis), and American educational institutions have become an essential training ground for foreign officials wanting to learn those techniques".

Data collection and statistical efforts in the medical field in the 19th century also translated to the emerging understanding of public health (Bashford, 2006, p. 70) and data collection from a broader population. The collection of broader public health data in the 19th century started with the 1830s outbreak of cholera in Europe. Bashford (2006, p. 70) argues that "Epidemiological intelligence, followed closely by programmes of international standardisation, were key ambitions of the interwar organizations, and these intelligence ambitions created changing orientations in lines of global communication". Therefore, with broader standardisation efforts and expanding technological capabilities, countries were able to exchange health information and engage in the "global" communication. Data was collected not only for the communication but also for the public governance purposes. Some literature defines the process of data collection for governance as "datafication", such as done by Pichelstorfer and Paul (2022, p. 3) in the case of exploring the global COVID-19 vaccination rates, where datafication is an "epistemic practice that is constitutive of how immunization becomes knowable and thus governable and functions to legitimize diplomatic interventions by the WHO". In their research, Pichelstorfer and Paul (2022, pp. 9-10) observe that "data need interpretation and never speak for itself"; "datafication, and the foregrounding of the seemingly technical character of producing numbers, allows WHO experts to engage, and by that intervene, in member states, but in a seemingly apolitical fashion that lends itself well to health diplomacy"; "data practices are performative, not only in influencing diplomatic practices, but also in shaping how WHO and UNICEF come to know and problematize"; and where data "practices themselves remain largely black-boxed". Therefore, the exchange of information between countries as well as how this information was collected and standardized, shows the underlying power relations and knowledge practices.

The health data collection and sharing efforts, especially if they are relevant to health threats, can be justified with a rationale of global and national (health) security, where countries present a rationale to protect themselves against health threats that spread globally. As argued by Lakoff (2017, p. 71), the global health security regime helps us to understand the countries´ preparations to protect themselves against the emerging infectious diseases "which are seen to threaten wealthy countries, and which typically (though not always) emanate from Asia, sub-Saharan Africa, or Latin America". Global health security regime, therefore, involves complex infrastructure consisting of

> "various organizations including multilateral health agencies, national disease control institutes, and collaborative reference laboratories and assemble diverse technical elements such as disease surveillance methods, emergency operations centers, and vaccine distribution systems" (Lakoff, 2017, p. 72).

All these infrastructures and technologies are envisioned by countries or other more global actors to help maintain global health security as well as prepare and prevent health threats. However, as further argued by Lakoff (2017) some countries are more active to protect themselves from the global health threats that are mainly envisioned to stem from the global South. One of the earliest examples of a

global health security regime and countries initiating it emerged in the United States in the 1990s (King, 2002) where the government particularly emphasised national security and economic interests that can be potentially threatened by emerging infectious diseases. In 1992, the National Academy of Science's Institute of Medicine in the United States released the report "Emerging Infections: Microbial Threats to Health in the United States". The report recommended funding health infrastructures in:

> "epidemiological surveillance of outbreaks of infectious diseases and the emergence of antimicrobial resistance; training and basic research in molecular biology and virology; public and private development of vaccines and therapeutic drugs; and the strengthening of and coordination between local, national and international public health institutions" (King, 2002, p. 768).

In the report, although the containment and management of infectious diseases were associated with the economic and security interests of the United States (2002, p. 770), the funding of the activities outlined in the example above considered other countries, usually from the global South. The vision was that building such infrastructures outside could help the United States to protect their interests internally in the end. To fulfil the rationale of global health security, global health surveillance efforts emerged that spread from a national to a global context. In 1997, the National Academy of Science's Institute of Medicine in the United States released the report "America's Vital Interest" which specified that the US scientific expertise

> "could be deployed in the service of international health: surveillance and information management, biomedical and biotechnological research, and the development and dissemination of pharmaceutical products" (King, 2002, p. 774).

The main goal of such a global network was "to allow for the rapid identification of local outbreaks of disease, ensuring that no incursion of microbes into the human population would go unnoticed" (King, 2002, p. 774). To implement these detection activities, the United States government "along with its counterparts throughout the world" pledged to "ensure that the regulatory, legislative, and market conditions necessary to attract private investment in telecommunications, information technology, and information services are in place", particularly in the "developing countries" (King, 2002, p. 774). To this end, the United States was foreseen to become both "the natural leaders and the most prominent beneficiaries of the creation of a global surveillance network" (King, 2002, p. 775). However, local populations and the lack of infrastructures presented obstacles of "incomplete integration into the modern projects of total surveillance and seamless exchange" (2002, p. 782), where the United States' role as a "natural" leader of global surveillance in the health field diminished.

Although earlier research emphasises that a global health regime is initiated and carried out by countries in the global North or global South, Stephenson (2011) explores and outlines other actors involved as well. Global health regime involves not just national countries but also other actors, such as international

organizations, pharmaceutical companies, NGOs, private global funds as well as different government agencies and departments within countries as well (such as health ministries, and defence departments, among others). One of the key actors within the global health security regime is perceived to be the WHO as explored by Stephenson (2011, p. 620). One of the first times that the WHO officially mentioned the concept of global health security was with its 2007 report "A Safer Future: Global Public Health Security in the 21st Century". The report outlined the need for a legal framework that would facilitate the communication of global "risks" and the key results of this report led to the revision of the IHR. Currently, infectious disease surveillance is endorsed by global health regulations that are supported by international countries and national countries governments. Stephenson (2011) further explores that the WHO carves itself out as a body responsible for coordinating global or public health safety, especially due to the challenges that the organization experienced in the second half of the 20th century:

> "As an international health agency, WHO has been weakened by decades of underfunding, strong criticism, and by the sudden emergence of much wealthier and more flexible actors in the field of global health" (p. 620).

As outlined by Mahajan (2021, p, 206), the International Health Regulations (IHR) adopted in 2005 by the World Health Assembly require countries to develop "disease surveillance and reporting tools; laboratory capacities for handling, examining and transferring biological samples; stockpiles for vaccines, antibiotics and other medical countermeasures; communication systems for emergencies; and sufficient hospital capacity". Therefore, these infrastructural capacities and technologies are outlined in the international regulations to prepare for and prevent global health threats and countries that sign IHR agree on "spending substantial health resources on surveillance" (Stephenson, 2011, p. 621). IHR also can be seen as surpassing the national authority as it assigns a variety of roles to the countries towards the WHO:

> "(…) it (IHR) increases the number of diseases for which the rules apply; expands the variety of events for which WHO must be notified; allows the organization to investigate, assess and declare public health emergencies of international concern and issue formal recommendations; requires the appointment of national health security focal points who liaise with WHO; requires states to develop their own capacity for disease surveillance, response and border control; obliges developed countries to assist developing countries in achieving these core public health capacities; and permits WHO to accept surveillance information from non-state sources" (Hoffman, 2010, p. 514).

Although such broad infrastructural or technological elements are needed to ensure global surveillance integration for infectious diseases, these requirements translate differently in the local contexts. For

instance, such global surveillance visions do not always reflect the domestic health priorities and resources available (Rushton, 2011, p. 2011). Global disease surveillance cannot be fulfilled only by building surveillance infrastructure, such as pathology laboratories (Mahajan, 2021, p. 208), as sustainable and long-term maintenance of such infrastructures and technologies is also required. For instance, Maxmen (2021, p. 333) explores the example of Liberia which received initial funding of USD 19 million from donors (mostly from the United States) after the Ebola outbreak in 2014-2016. However, in 2019, the country still could not carry out infectious disease surveillance because of the "nationwide shortages in biomedical supplies", such as the missing tubes to collect blood and other samples, and the lack of finances to pay wages for researchers and healthcare workers to conduct surveillance. Therefore, global surveillance requires not only building infrastructures in local contexts but also resources to maintain the whole health system and other infrastructures, including transportation or education systems.

Despite the numerous infrastructural and technical limitations in some local contexts that hinder (global) surveillance, the current global disease surveillance efforts continue to evolve, especially given the developing technologies, such as artificial intelligence (AI) and big data. During the 20th century, data collection and analysis started to spread not only among national countries but also started to include virtual spaces, became digital and enabled more data points to be collected and connected to certain individuals. For instance, in the field of medicine, increasing data collection allowed the comparisons between different data and individuals to whom this data was assigned:

> "During the 20th century, that knowledge came increasingly through numerical digits located in dimensional spaces (…) Whatever the measurement scale, people could be ranked and distributed in virtual space. While the temperature chart had connected data points marking body temperature for a single patient, the new data points of punch cards, graphs, correlations and controlled answer questionnaires enabled the juxtaposition of data points from many individuals" (Armstrong, 2019, p. 114).

Roberts and Elbe (2017, p. 46) further argue that security questions in the global health field and data collection efforts further drove the development of faster and more effective surveillance technologies, where "efforts to strengthen global health security are major drivers in the development and proliferation of new algorithmic security technologies" in the disease areas that can be understood as global threat, such as "HIV/AIDS, Severe Acute Respiratory Syndrome (SARS), pandemic flu, Middle East Respiratory Syndrome (MERS), Ebola and Zika". Their analysis shows that surveillance systems become "progressively more reliant upon algorithms to mine an ever-growing volume of indirect data sources for the earliest signs of a possible new outbreak – gradually propelling algorithms into the heart of global outbreak detection" (2017, p. 46).

Even if all infrastructures and technologies are in place and everywhere that could enable global health data surveillance, health data sharing, especially globally, remains highly political. The complexities of surveillance in the global health field come to data sharing, particularly as it is supposed to happen between different national countries with different visions, needs, expectations, and concerns in the global health field. Elbe (2021) explores these complexities with the notion of "bioinformatical diplomacy" which looks into the health data sharing within "the emerging field of tensions, sensitivities, practices and enabling instruments surrounding the timely international exchange of bioinformation about global health emergencies" (2021, p. 657). Elbe´s research shows that health data sharing is tightly interconnected with "sovereignty, power and security in international relations" as well as "subtler political, economic and security dynamics involved in passaging digital sequence data across diverse sovereign, geopolitical and North-South divides" (2021, p. 659). In addition, one of the caveats of IHR relates to the unclarities of what constitutes public health information or what health data should be shared globally as the regulation does not outline what specific information should be shared among the countries (Stephenson, 2011, p. 633). Therefore, given the tensions between the countries on data sharing as well as the lack of robust global regulation for this, automatic data collection in virtual spaces and the use of algorithms could be seen as a solution to overcome such global health data sharing issues. However, such visions of real-time data, big data and AI are still only envisioned as something to be achieved in the future, especially in the global health field.

However, in the global health understanding, the surveillance could relate not only to the global health security regime, where countries want to protect themselves against global health threats, usually perceived to come from the global South, but also to the rationale of helping others, saving lives, and being effective while doing so. This also corresponds to the global health regime of humanitarian biomedicine that focuses on "diseases such as malaria and tuberculosis (TB) that currently afflict large numbers of people in places where treatment is difficult or impossible to access" as well as bringing "advanced diagnostic and pharmaceutical interventions to those in need" (Lakoff, 2017, p. 72).

In the global health field, the increasing data collection on individuals and their health is also linked with the epidemiological thought style, expertise, the epidemiologists´ understanding of saving lives, and philanthropic efforts that invest in global health initiatives, including disease surveillance. For instance, Reubi (2018) explored the Global Adult Tobacco Survey (GATS) carried out by the Centers for Disease Control and Prevention (CDC) in the United States and the WHO. This global collection of data and epidemiological surveillance is based on the "belief that efforts to save lives need to be based on rigorous data to be effective" (2018, p. 84) which comes from "the central tenets of epidemiological reason – the will to save lives, the belief in the importance of data, social surveys, epidemiologists and global population" (2018, p. 87) that evolved over time. At the same time, epidemiologists seek to provide evidence for decision-making and show the effectiveness of the potential (global) health intervention. As explored in the discussion outlined by Sariola et al (2017) between epidemiologists,

STS researchers and activists on AMR, epidemiologists seek to inform the evidence-based policies in the public health field, where they: "don't want to go back to the days when the WHO made policies based purely on expert opinion. We need to know what works, do cost-effectiveness analyses and systematic reviews of the evidence and when there is no data we can model it" (2017, p. 4). Therefore, epidemiologists envision informing the public health management decisions based on health data and systematic health surveillance should help retrieve this data which is a key tool for public health management and making it effective:

> "On-going, systematic surveillance is a key public health tool. It guides programme implementation. It makes it possible to monitor results and evaluate whether interventions are effective … Surveillance provides critical information … Who smokes? Where? How much? Who is doing what in terms of policy? … If you cannot measure it, you cannot manage it" (Sariola et al, 2017).

Data collection and surveillance become an important aspect not only for public policy managers but also for the funders that invest in different global health initiatives for audit and monitoring purposes for their investments. As global health funders are often funded by bigger corporations, they adopt some of the business practices of audit and monitoring to be effective. For instance, disease surveillance can be enabled and funded by different philanthropic institutions that

> "have been particularly keen to invest is the development of new global health metrics, with many of them funding transnational surveillance systems and epidemiological research projects. Gates and Bloomberg's financial support of the IHME's Global Burden of Disease project and the CDC's GATS – which are critical to contemporary epidemiological reason – are cases in point" (Reubi, 2018, p. 97).

Reubi continues that the funding by philanthropic organizations, such as Gates Foundation, to the surveillance and data collection can also relate to the business practices of audit and monitoring:

> "Given their commitment to data and audit practices, it is perhaps no surprise that both Gates and Bloomberg saw the metrics and surveillance systems developed by epidemiologists as the perfect tool to monitor and assess their charitable efforts in global health" (2018, p. 97).

Therefore, health data collection and surveillance efforts can be informed by the rationale of saving lives and helping others, even globally. However, this understanding is also tied to the need of being effective and having concrete evidence to support the decision-making processes, despite the numerous infrastructural and technological challenges that can affect (global) surveillance endeavours. To this end, health data could be seen as a source of "unbiased" knowledge that could help experts and policymakers in decision-making, particularly during a health crisis. For instance, during the COVID-19 pandemic, one of the ways to perform "unbiased" or objective expertise to support decision-making

was through data collection and modelling efforts, such as tracking the number of persons infected, tested, or a number of deaths (Harrison & Pardo, 2021). However, data cannot be "unbiased" as it does not speak for itself (Redman, 2014) and it can hide broader societal inequalities related to data collection. For instance, data-based expertise and decision-making practices might ignore the missing data (e.g., persons lacking access to medical care, or from whom data was (not) collected) or broader global health inequalities (lack of infrastructures in some countries to ensure data collection and sharing) (Milan & Treré, 2020).

To this end, the epidemiological thought style can be contested and reshaped by some of the epidemiologists themselves as shown by Prussing (2020). Erica Prussing (2020) used ethnographic methods to show how epidemiologists perform "the forms of expertise that researcher/practitioners enact as they conduct research that simultaneously harnesses epidemiology's persuasive power in social worlds like public health and public policy, while also critically challenging legacies of colonialist erasures and misrepresentations of Indigenous health in population statistics" (pp. 1142-1143). In this research, Prussing (2020) looks at how researchers from Indigenous communities in New Zealand and the United States with epidemiological training and expertise challenge and work with health statistics that entail colonialist history and inequalities, such as smaller communities not producing statistically significant results in comparison to the "global" estimates. However, such a critical view of broader epidemiological thought style can be resisted by established scientific practices, such as conferences or peer-reviewed journals where "good" scientific practices, such as statistically significant results are required and that omit social aspects from the health statistics.

Overall, there are different modes of counting in the global health field. While evidence-based decision-making and datafication are important to the overall global health field, differing understandings of global health regimes (Lakoff, 2017) show different ways of counting. Within the global health security regime, surveillance efforts are prevalent that is based on the need for countries to protect themselves, the differences between the Global North and Global South, some actors being involved more than others (e.g., the United States government, the WHO), the legislation involved, such as IHR, as well as infrastructures and technical capabilities needed for the surveillance. On the other hand, the understanding of humanitarian biomedicine emphasises the epidemiological thought style of saving lives. Counting within this regime involves surveys where less infrastructural and technological capabilities are needed; collecting data on behaviours and lifestyles; as well as using such data for the decision-making of funders who invest in global health projects. Overall, these differences show the complexities in the differing understandings of global health and the different actors and expertise involved in the field.

3. Assembling a case study

3.1. Case study

As a case study, I choose to explore the Global Antimicrobial Resistance and Use Surveillance System or GLASS which was established in 2015 and is currently coordinated by the WHO. Below, I outline the rationale of what led to the GLASS establishment and the actors that supported it the most visibly as well as GLASS goals and the main activities for global AMR data collection and standardisation. I also present why GLASS is an insightful case study to explore in the context of this thesis.

As presented in the State-of-the-Art section, AMR has been known as a potential threat since the development of antibiotics. Although the first efforts to address AMR globally appeared in the 1990s to 2000s, the high-level political response started somewhat in the mid-2010s, which is often assigned to the political figure of Professor Dame Sally Davies from the United Kingdom who was a Chief Medical Officer in that time. Professor Davies raised the threat of AMR and compared its effects to the ones of climate change. The high-level political attention maintained the momentum and, in 2015, members of the World Health Assembly agreed on five objectives to address antimicrobial resistance (AMR) on a global scale. The World Health Assembly then adopted the Global action plan on antimicrobial resistance (GAP on AMR) which is often held as a global blueprint for AMR response.

The GAP on AMR outlines five objectives on how to address antimicrobial resistance on a global scale. The second objective "to strengthen the knowledge and evidence base through surveillance and research" (World Health Organization, 2015a) resulted in the Global Antimicrobial Resistance and Use Surveillance System (GLASS) established in October 2015 under the WHO. The overarching goal of the GLASS is to "continue filling knowledge gaps, to inform strategies at all levels" (World Health Organization, 2022a) on national, regional, and global scales to address the global threat of AMR. To achieve this goal, GLASS advocates and supports the standardisation of the global collection, analysis and sharing of AMR data. The surveillance "provides a standardized approach to the collection, analysis and sharing of national AMR data in samples collected routinely for clinical purposes for a set of pathogens that cause common bacterial infections in human" (World Health Organization, 2022a). However, the preparation for the GLASS establishment did not start with the GAP on AMR in 2015 as the previous action to collect evidence on the need for global AMR surveillance was collected and published by the WHO.

Before the GLASS establishment in 2015, WHO documents shaped AMR as a threat to modern medicine and particularly as a threat to human health. One of the WHO´s documents that particularly shaped the AMR threat in the mid-2010s was the Global Report on Surveillance published in 2014. This document served as a baseline research report to carve out the gap for the establishment of the GLASS, namely the standardized AMR surveillance globally. This need was based on the future threat

and the rationale of preparedness. The report presented AMR threat to have dire consequences in the future, where "A post-antibiotic era—in which common infections and minor injuries can kill—far from being an apocalyptic fantasy, is instead a very real possibility for the 21st century" (World Health Organization, 2014, p. IX). The report continues presenting results based on desk research and literature reviews on a number of resistant bacteria – pathogens – and estimates of their effects on human health. For instance, the report found that the pathogen of *K pneumoniae* (bacteria that can cause pneumoniae or bloodstream infection) causes a high AMR health burden with high mortality rates, especially in vulnerable patients:

> "The mortality rates for K. pneumoniae hospital-acquired pneumonia depend on the severity of the underlying condition, and can exceed 50% in vulnerable patients, even when treated with appropriate antibacterial drugs" (World Health Organization, 2014, p. 15).

The report also stated that many of the available antibiotics are becoming ineffective which leads to negative patient outcomes (such as death, increased hospital stays, and disability, among others) and increased healthcare expenditures due to the longer hospital stays, prolonged time of patients being on sick leave and away from work, unemployment, or negative economic effects to patients´ families if additional and prolonged care is needed (2014, p. IX). Therefore, the report continued to not only carve out AMR threat to human health but also showed that AMR can have negative economic effects on patients and their families.

The AMR threat to modern medicine and human health in the WHO documents goes hand in hand with negative economic impacts, mainly related to the increased spending on healthcare. The WHO's Global Report on Surveillance of 2014 illustrates this as the report's authors systematically reviewed the literature on resistant pathogens towards existing antimicrobials. For one of the pathogens *E. coli* (which can cause stomach cramps, diarrhoea, vomiting, and fever) the report found that:

> "Patients with infections caused by bacteria resistant to a specific antibacterial drug generally have an increased risk of worse clinical outcomes and death, and consume more health-care resources, than patients infected with the same bacteria not demonstrating the resistance pattern in question" (World Health Organization, 2014, p. XII).

The report also further used some estimations for the *Candida fungus* pathogen (which can cause yeast infections). Similarly, the resistance of this pathogen causes high mortality rates and increased healthcare expenditures:

> "Invasive Candida infections have been reported to be associated with high morbidity and mortality (mortality of approximately 35%), as well as higher health-care costs and prolonged length of hospitalization (46, 47). Patients with resistant infections may

> experience a delay in receiving appropriate therapy, which can increase costs, LOS, and morbidity and mortality (48, 49).” (World Health Organization, 2014, p. 64).

Therefore, resistant bacteria can cause not only death or long-term illness in patients who, as a result, are presented as not being able to contribute to the economy anymore, but their treatment is also presented as more costly. The report further engages with reviewing the economic costs of candida infections estimated by the Centers for Disease Control and Prevention (CDC) in the United States:

> “In 2005, CDC estimated that each case of Candida infection results in 3–13 days of additional hospitalization, and incurs a total of US$ 6000 to US$ 29 000 in direct health-care costs (46). Based on current data and projections, these infections add a total of US$ 8 billion to US health-care expenditures every year (44, 46, 49, 50).” (2014, p. 64).

All of the case studies of pathogens explored as a baseline by the WHO’s Global Report on Surveillance of 2014 are now included in the current GLASS AMR surveillance efforts. The WHO’s Global Report on Surveillance of 2014 engaged in the review of the following “bacteria of international concern” (2014, pp. X-XII):

- Escherichia coli: can cause stomach cramps, diarrhoea, vomiting, fever
- Klebsiella pneumoniae: can cause pneumonia or bloodstream infection
- Staphylococcus aureus: can cause skin infections, pneumonia, meningitis, or sepsis
- Streptococcus pneumoniae: can cause sinusitis, pneumonia, meningitis
- Nontyphoidal Salmonella: can cause gastroenteritis, high fever, diarrhoea
- Shigella species can cause diarrhoea, fever, and stomach cramps
- Neisseria gonorrhoeae causes sexually transmitted infection of gonorrhoea

These pathogens are now included in the GLASS AMR data collection efforts. The selection of these particular pathogens is based on the rationale of the increasing resistance to particular antibiotics. In the foreword of the WHO’s Global Report on Surveillance of 2014, Dr Keiji Fukuda (WHO’s Assistant Director for Health Security) labelled the selected pathogens for the report as “pathogens of major public health importance” (2014, p. IX). The bacteria were selected because “they are common and represent areas of infection where there is increasing resistance to drugs of last resort” (World Health Organization, 2015c, p. 9). Here, we can see that GLASS pathogen selection also corresponds to the antibiotics of the last resort, namely antibiotics that do not have alternatives if a resistant bacteria cannot be treated with them.

Overall, the baseline WHO document for the GLASS establishment - WHO’s Global Report on Surveillance of 2014 – conducted a literature and document review on the AMR threat and the selected list of pathogens as presented above. Following this review of the selected pathogens, the WHO´s

Global Report on Surveillance concluded that there is a knowledge gap on AMR and that more data is needed to fill in this knowledge gap on the AMR threat and the selected set of resistant pathogens: "The magnitude of the problem worldwide and the impact of AMR on human health, and on costs for the health-care sector and the wider societal impact, are still largely unknown." (2014, p. XIX).

The report concluded that to counter AMR threat and to find appropriate responses, reliable data is needed, and it could help to close this knowledge gap: "Surveillance that generates reliable data is the essential basis of sound global strategies and public health actions to contain AMR, and is urgently needed around the world" (2014, p. XIII). This knowledge based on data could be particularly helpful to "improve our understanding of AMR dynamics and to inform containment and mitigation strategies" which should help to contain AMR threat globally. (World Health Organization, 2017b, p. v). To fulfil these goals, documents emphasise a need for "good evidence", particularly from a global surveillance system that could also help to maintain the momentum for global AMR action:

> "Dr Emiroglu said AMR was high on the political agenda but Member States would not be able to create the necessary momentum to address AMR unless the global action plan was implemented using good evidence from surveillance systems" (World Health Organization, 2015c, p. 7)

Overall, the global attention to AMR as well as the GLASS as a global AMR surveillance system mainly started at a high political level and involved actors, such as United Nations, World Health Assembly, and the WHO. However, some of the national countries were particularly visible to encourage the solutions addressing AMR on a global scale and as suggested by the WHO. For instance, right after the GLASS establishment, the WHO documents presented reports from high-level political meetings, where the need for global AMR surveillance was emphasised at the request of the national countries. Sweden emerged in the WHO documents as one of the most active countries in pushing towards global AMR surveillance efforts. In the meeting organised in 2014 in Sweden by the Swedish Ministry of Health and Social Affairs and the Public Health Agency of Sweden, the representatives of the invited countries reaffirmed the WHO's approach to surveillance with the establishment of the GLASS:

> "30 WHO Member States, from all WHO regions, reaffirmed the need for a global programme for surveillance of AMR of relevance to human health, to form the basis for local, national and regional action and to monitor the effectiveness of interventions. Participants in the consultation also agreed on the surveillance approach proposed by WHO" (World Health Organization, 2015b, p. 1).

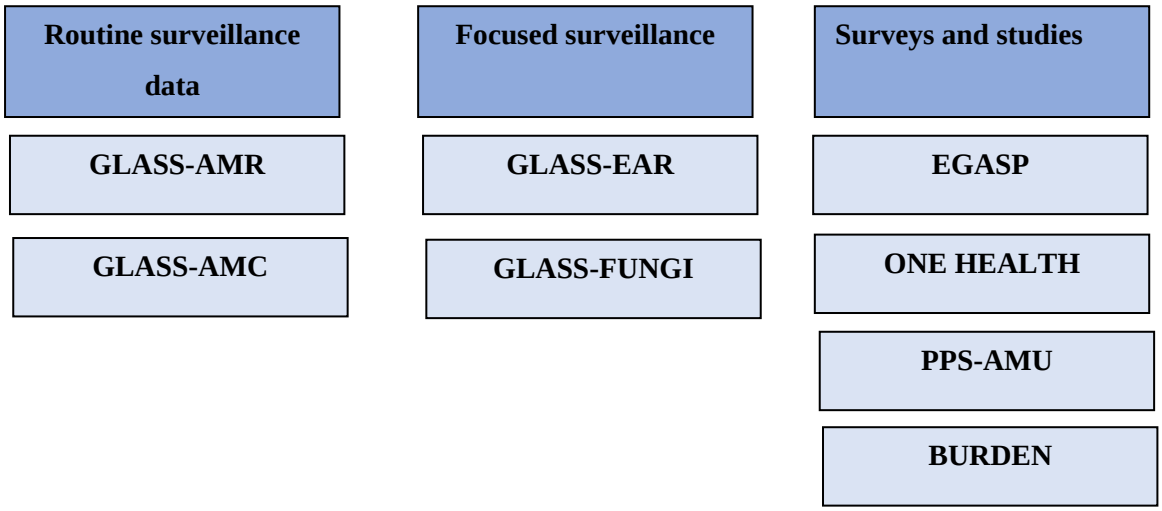
However, among the 30 WHO member states who participated in the meeting, most of them were European, had functioning AMR surveillance systems embedded in working healthcare infrastructures, and submitted their AMR data to the European AMR surveillance system of EARS-Net. The document

does not present any different visions or opinions by countries or regions that do not have the required infrastructures or capabilities for global/regional/national AMR surveillance.

Using the momentum created in the mid-2010s, World Health Assembly together with member states approved the Global Action Plan on AMR in 2015 (World Health Organization, 2015a), while the second objective: "Strengthen the knowledge and evidence base through surveillance and research" directly enabled the creation of the GLASS in the same year. The GAP on AMR also refers to the WHO's Global Report on AMR surveillance published a year ago that carved out the gap for a need for global AMR surveillance as no standardised information on AMR and its effects was available or the information provided too many gaps.

The GLASS surveillance activities were shaped into three horizontal levels, namely routine data surveillance, focused surveillance, and surveys and studies (see figure below).

Figure 1. GLASS Surveillance activities



The widest effort with the most data collected is the GLASS-AMR module under routine data surveillance which collects data on eight selected priority pathogens[1] from samples obtained from humans. The collected samples then undergo susceptibility testing in the laboratories where the priority pathogens are "isolated from clinical specimens (blood, urine, stool and cervical and urethral specimens)" (World Health Organization, 2022a). These samples are collected in surveillance sites (in- and out-patient clinics) and then sent to the National Reference Laboratories and AMR results are shared back with the surveillance site for diagnostic purposes as well as with the National Focal Point (usually public health institute or health ministry of a national country) which shares data with the GLASS and/or other regional/national AMR surveillance system. In addition, the antimicrobial susceptibility testing carried out in laboratories should adhere to the standards of the European Committee on Antimicrobial Susceptibility Testing (EUCAST) or the Clinical and Laboratory Standards Institute (CLSI) to ensure

[1] Acinetobacter spp., E. coli, Klebsiella pneumoniae, Neisseria gonorrhoeae, Salmonella spp., Shigella spp., Staphylococcus aureus, and Streptococcus pneumoniae.

data quality and AMR testing standardisation. Other modules under routine data surveillance include the GLASS-AMC module on antimicrobial consumption surveillance.

The focused surveillance level of the GLASS includes the modules of GLASS-EAR module on Emerging Antimicrobial Resistance Reporting and the GLASS-FUNGI module on AMR surveillance of invasive fungal infection. The GLASS-EAR module works on early and fast detection of unusual and emergency AMR events as the GLASS-AMR module under routine surveillance collects AMR data once a year. Therefore, the GLASS-EAR module allows member countries and WHO to share unusual AMR findings at any time. Meanwhile, the GLASS-FUNGI module focuses on AMR data collection on fungal infections and measuring resistance towards antifungal medicine. Therefore, both modules under the focused surveillance prioritise either a fast data sharing of unusual AMR events or data sharing on fungal infections and complement the routine AMR surveillance.

The third level of GLASS surveillance contains studies and surveys. This level involves four modules: "Enhanced Gonorrhoeae Surveillance" (EGASP), "Integrated multi-sectoral surveillance" (ONE HEALTH), "Point prevalence survey on antibiotic use in hospitals" (PPS-AMU), and "Studies for estimating antimicrobial resistance burden" (BURDEN) (World Health Organization, 2022a). Overall, GLASS data level on surveys and studies collects additional AMR data that are not usually collected with laboratory-based AMR testing within a routine or focused surveillance. The "Enhanced Gonorrhoeae Surveillance" or EGASP module is built on the previous WHO surveillance efforts in the *N. gonorrhoeae* pathogen monitoring on a global scale that started in the 1990s. The module aims to collect additional patient data for resistant *N. gonorrhoeae* pathogen monitoring. Meanwhile, the "Integrated multi-sectoral surveillance" or ONE HEALTH module was established in 2018 to observe the resistant *E. Coli* bacteria in humans, animals and the environment in selected sites. Lastly, PPS-AMU studies how patients and healthcare staff use and prescribe antibiotics to better understand AMR and create potential interventions for antibiotics misuse.

The need for the BURDEN data module was already carved out in 2014 by the WHO. Next to the need for standardised global AMR surveillance, the WHO emphasised a need for standardised AMR health burden data. The WHO's Global Report on Surveillance of 2014 carved out the need for global standardised AMR health burden estimations as well. In the report, the authors stated that the AMR health burden:

> "cannot be fully assessed with the presently available data; new methodologies are needed to more precisely assess the total impact of resistance, to better inform health policies and to prioritize the deployment of resources" (World Health Organization, 2014, p. 69).

Such healthcare burden estimations could not only help to understand the real threat of AMR to human health but are also envisioned by the WHO to help the national governments to prioritise their healthcare

spending, including further funding for AMR surveillance as well as raising public awareness of AMR (World Health Organization, 2018b, p. 2). This was emphasised by one of the interviews conducted for this thesis that answered the goal of AMR health burden estimations:

> "I think one of the things is really to put AMR on the political agenda. It's often called a silent pandemic because we know there's people dying because of drug-resistant infections but it's not so visible. And that's why there hasn't been that much funding for research, for example. So, by trying to put it on political agenda, we hope to have more money available for surveillance, for research, and for solutions" (Interviewee IV).

Therefore, GLASS not only engages with the standardisation of AMR data collection but also in the harmonization of AMR health burden estimations, in line with other studies for global AMR health data collection.

WHO envisions GLASS to be a global AMR surveillance system. In line with existing AMR surveillance efforts, WHO assembles GLASS as a global and also as central AMR surveillance system as presented by one of the interviewees:

> " I think, WHO, they just, I think, they're just more focused on setting the agenda themselves and they expect the regional offices to be supporting that and making sure their efforts feed into that. Yeah, I mean, I see in general they wouldn't approach other (AMR surveillance) networks, so say for (X surveillance system), kind of out of the courtesy, we would approach them and say, yeah, this is what we are doing, are you interested? Yeah, I see in general, they are keen to assert their position as the kind of central system" (Interviewee III)

Overall, since the mid-2010s, a number of high-level meetings and public figures emerged who endorsed the global need to address the AMR threat on global, regional, and local levels. The Global Action Plan on AMR (World Health Organization, 2015a) emerged as one of the blueprints that outlined the objectives of how AMR could be tackled, including the global surveillance of AMR. A direct outcome of this objective was the GLASS as a global AMR surveillance system. One of the goals of the GLASS was not only to collect AMR data globally for knowledge creation but also to standardize and coordinate the existing AMR surveillance systems on national and regional levels. As the GAP on AMR was endorsed by the member countries of the World Health Assembly in 2015, the World Health Organization (WHO) assumed a key role in coordinating these objectives. This also includes coordinating the Global Antimicrobial Resistance and Use Surveillance System (GLASS) that was launched in 2015. However, at the same time, while coordinating and shaping the global objectives, including AMR surveillance, the WHO cannot directly implement surveillance systems in national and regional contexts. Therefore, the WHO relies on local understandings and actions towards

implementing AMR surveillance systems in a way that corresponds to the WHO´s vision of a standardized global AMR surveillance system. To this end, the WHO and the GLASS surveillance efforts are an interesting research case showing how the global visions of AMR response, surveillance, and global health overall are built by the knowledge practices and WHO´s navigation of embedded power relations within the global health field as well as how the global visions of AMR response and surveillance correspond to the local complexities and agendas by other global health actors.

Overall, the case of the GLASS as a global AMR surveillance system explored in this thesis could show how "global" is assembled by the WHO and how such assemblage corresponds to the local complexities as well as other agendas by actors in the global health field. As emphasised by Chandler (2019), such "explorations render visible the ways social, economic and political frames continue to define AMR and how it may be acted upon, which opens up possibilities for reconfiguring AMR research and action". Therefore, this thesis aims to open the ways on how the WHO assemble the global response to global health threats, such as AMR and intends not only to show how AMR and AMR surveillance are understood and assembled but also what else could be seen and taken into account while implementing global solutions, such as AMR surveillance. In addition, Chandler (2019) sees the "possibilities for reconfiguring AMR research and action by shifting the focus of attention across scales and enabling different forms of care, and different publics, to come into view". Therefore, while looking into the publicly available WHO documents about the GLASS and drawing from the expert interviews, this thesis explores which global and/or local practices and publics are mentioned more than the others and such explorations could potentially provide ideas for the future AMR research, actions, and understandings about AMR and its surveillance globally or locally.

3.2. Research question

This thesis particularly engages with the topic of AMR and one of its suggested global solutions, such as data collection and knowledge production via surveillance and its standardisation. AMR is an increasingly important topic in the global health field, however, it shows a specific part of the global health field as AMR is also a more complex issue than the governance of a particular infectious disease. Exploration of AMR and its envisioned global solutions, such as surveillance, can show how we understand, govern, and assemble the "global" in the global solutions, including the global health field, as well as the underlying tensions and resistances in such endeavours. Such assemblages show how we understand, envision, and prepare for global challenges as well as the complex interactions, tensions, and understandings between the global and the national or local contexts, different experts, stakeholders, ways of knowing, and relations between the Global North and Global South. Based on the State of the Art and the selected case study of GLASS assembled by the WHO as a global AMR surveillance system, my main research question is:

How is the "global" in global health assembled within the embedded power relations in the global health field and the knowledge practices of the World Health Organization (WHO) through the implementation of the Global Antimicrobial Resistance and Use Surveillance System (GLASS)?

To answer this research question, I will use the following three sub-questions:

SQ1: How does the WHO navigate the embedded power relations in the global health field while assembling GLASS?

The WHO works in a crowded global health field with a variety of other international organizations, countries, and stakeholders with varying interests and priorities. Therefore, with this sub-question, I will look at how the WHO presents the rationale in its assemblage of the GLASS; how it assembles GLASS in a top-down and bottom-up way, how it enables the countries´ participation in GLASS, and how it deals with other forms of expertise: either within the WHO itself or outside, in the global health field.

To answer this question, I will combine methods of document analysis and interviews. While documents mainly present the rationale and ways of how the WHO envision working with the involved stakeholders, interviewees also talked about the alternatives and resistance to the GLASS methodology as a global surveillance system. The element of resistance towards GLASS is often omitted from the publicly available documents, while documents show some traces of how such resistance or alternative suggestions to GLASS methodology of global AMR surveillance are managed or not presented publicly.

SQ2: On what knowledge practices and expertise does the WHO draw on while assembling GLASS?

Through this question, I will look at what knowledge practices the WHO implement while assembling the "global" in GLASS activities, namely AMR data collection, testing, and analysis/interpretation as well as what expertise and rationale lie behind them.

The basis of this question will be answered by looking into different GLASS data collection efforts. Overall, GLASS surveillance activities are based on three horizontal levels, namely routine data surveillance, focused surveillance, and surveys and studies. These activities collect AMR data by different methods and involve different types of expertise. The widest effort with the most data collected is the GLASS-AMR module which collects data on eight selected priority pathogens from samples obtained from humans. The collected samples then undergo antimicrobial susceptibility testing (AST) in the laboratories where the priority pathogens are "isolated from clinical specimens (blood, urine, stool and cervical and urethral specimens)" and tested with a particular antimicrobial, looking if the pathogen is resistant or not (World Health Organization, 2022a). The antimicrobial susceptibility testing carried out in laboratories should adhere to the standards of the European Committee on Antimicrobial Susceptibility Testing (EUCAST) or the Clinical and Laboratory Standards Institute (CLSI) to ensure data quality. Human samples for AMR testing are collected in surveillance sites (in- and out-patient clinics) and then sent to the National Reference Laboratories and AMR results are shared back with the surveillance site for diagnostic purposes as well as with the National Focal Point (usually public health institute or health ministry of a national country) which shares data with the GLASS and/or other regional/national AMR surveillance system. The results of such data sharing are then presented in the GLASS yearly reports as well as on the WHO website.

Another level of surveillance is focused surveillance which encompasses the modules of emerging AMR surveillance (GLASS-EAR) as well as resistant fungi infections surveillance. The third level of the surveys and studies module of the GLASS includes several modules on additional epidemiological data collection for different resistant pathogens. One of the key modules on this level is the AMR health burden estimations (or the BURDEN module). This module aims to estimate how many deaths were caused by antimicrobial-resistant bloodstream infections. Such estimates would be generated via surveys which collect patient observations, while they are in the hospital (World Health Organization, 2022b), while laboratory testing is also needed to determine whether the patient had a resistant infection. Although currently GLASS only focuses on mortality attributable to the AMR, its long-term goal is to calculate and standardize AMR burden with Disability-adjusted life years (DALYs) on a global scale.

I will answer this sub-question while looking into how different expertise (mainly from laboratories, epidemiologists, and clinicians) in these data collection efforts correspond to the GLASS modules and where the potential tensions arise. This will also allow us to see more predominant WHO knowledge practices while assembling GLASS as well as which tensions remain in the background. For scoping reasons, I will not engage with the GLASS modules on antibiotics consumption as such activities only started in 2020 and GLASS provide only a couple of documents about these activities.

To answer this sub-question, I focus on document analysis and interview methods. While the WHO´s position is mainly presented in the documents, interviewed stakeholders presented either aligned or differing perspectives on the methodology of GLASS as well as it being a global AMR surveillance system.

SQ3:What conditions, complexities, and resistances are not adequately presented in the GLASS standardisation practices?

With this sub-question, I particularly look at the standardisation of AMR surveillance efforts and what is envisioned as a "global" AMR surveillance system based on the previous two sub-questions outlined above. Through this sub-question, I aim to explore what other conditions, complexities, and resistances concerning the embedded power relations in the global health field and knowledge practices enacted by the WHO are silenced or not prioritised in the publicly available discourses while assembling the global AMR surveillance via GLASS. Therefore, this sub-question helps to explore what is left out of the global assemblage of the GLASS, for instance, what stakeholders, expertise, or data collection practices. This also relates to the main research question as it can show what expertise and knowledge are more prominent and prioritized in practices and solutions that are perceived as "global" in the global health field.

To answer this question, I focus on document analysis and interview methods. These methods also show what is (not) visible in the publicly available discourses provided by the GLASS documents in comparison to the accounts provided by the interviewed stakeholders on the other response to the GLASS implementation as a global AMR surveillance system.

3.3. Materials and methods

To answer my research question, I have combined methods of document analysis and interviews.

3.3.1. Document analysis

3.3.1.1. Document collection

In this thesis, I follow the definition of the document provided by Shankar, Hakken, and Østerlund as "any artefact that includes substantial references to the social processes through which it was produced and reproduced" (2017, p. 59). In this thesis, the documents refer to the electronic artifacts produced by the WHO on GLASS which take the forms of websites and reports or other types of documents, usually in pdf format. These documents refer to and tell about the GLASS objectives, goals, progress, methodologies, meetings, expert discussions, and other information which is all contained under the WHO website and have the WHO logo on them. I also perceived the documents as self-explicating, meaning that these "documents address a broad and heterogeneous audience and thus can rely very little on readers bringing background knowledge" (Shankar et al, 2017, pp. 70-71). As GLASS documents intend to address a "global" audience and a variety of stakeholders, they provide plenty of background

information, with some of its reports reaching several hundred pages. This was also helpful in analysing the documents and seeing how the WHO envisions AMR threat, GLASS methodology, and other topics. At the same time, some of the chapters, especially on laboratory methods and provided in the annexes of the documents were more technical and "written for a very narrow group or maybe even an individual and thus lean heavily on the writer's or reader's background knowledge" (2017, p. 72).

In this thesis, documents are also the tools of the WHO that are (Asdal, 2015, p. 74) "working upon, modifying, and transforming that reality" of AMR and AMR surveillance on different scales. As it is outlined in the empirical part, the definition of AMR and AMR surveillance methodologies can differ within local contexts and other existing global standards. However, with its documents, WHO actively assembles the global AMR surveillance system of GLASS as well as shapes the local surveillance systems by providing methodologies of how global AMR data should be collected as well as providing the AMR rates results in the WHO reports and dashboards that allow seeing AMR rates between the different countries. WHO documents on GLASS do not only "document" the practices for AMR surveillance but are also tools to shape the local practices as well or, as Asdal (2015, p. 77) puts it that "Instead of merely describing the same objects and issues simply from different angles, documents may take part in modifying and transforming issues". To this end, WHO documents work as tools helping to assemble GLASS as a *global* AMR surveillance system.

I have collected 30 documents related to the GLASS methodology and yearly implementation reports from the dedicated section presented on the WHO's general website (World Health Organization, 2022a). I have observed three types of documents, such as the methodological guidance documents on how to collect AMR data and share it in a standardized way; meeting reports that contained meeting minutes from the meetings with representatives from GLASS, WHO, national countries and regional surveillance systems, and yearly reports on GLASS progress and AMR data collection. The GLASS methodology documents guide how AMR data should be collected and shared. This methodology mainly concerns laboratory-based methods for AMR data collection and analysis. Usually, each of the GLASS data modules has at least one document. Meanwhile, meeting reports present rather detailed minutes on the presentations and discussions among the WHO experts, national countries' representatives, and a variety of stakeholders concerning global AMR surveillance. Lastly, the yearly GLASS implementation reports present information about what was done in the year, such as the progress of AMR surveillance structures, updates on their establishment and/or maintenance, as well as yearly AMR rates and results drawn from these insights.

The first round of document collection occurred in the summer semester of 2021, where I collected 48 documents. I have also experienced some of the challenges referred to by Shankar et al (2017, p. 59), where digital documents and online spaces where they are found can be changed that "often make interpreting documents substantially more difficult". The WHO website and GLASS sections were updated in the second half of 2022, meaning that many links to the documents and GLASS section were

renewed. However, I managed to collect documents before these changes were made and I did not intend to analyse the WHO website and GLASS section on its own, although I noticed some interesting changes, such as the lessened use of the phrase "evidence-based decision-making" in the GLASS website section.

I have then refined the list of documents and shortened the initial list to adhere to the limited scope of this thesis, especially as some of the documents, such as yearly reports can contain several hundred pages. I finalised this stage approximately in June 2022, therefore, any documents published after this date by the WHO on GLASS are not included in the analysis, for example, "Global antimicrobial resistance and use surveillance system (GLASS) Report: 2022". Although it is an important yearly report, it was published on 9th December 2022, therefore, I could not properly analyse it and include it in the thesis due to the documents´ coding and analysis timeline.

In the second round of document collection, I have excluded a variety of infographics and posters by the WHO on AMR and AMR surveillance, PowerPoint presentations by the experts, and files showing the changes in yearly AMR rates among countries that submitted their data to the GLASS, as well as documents that consider methodology on antibiotics consumption and its global surveillance practices envisioned by the WHO. However, although these documents were removed, most of the information that they contained was summarised in the GLASS yearly reports. In addition, considering the significant length of some of the WHO documents, I have prioritised some of the sections over the others within each of the documents. The sections from the document that I excluded mainly concerned the technical aspects of AMR testing and laboratory methodologies that require more thorough knowledge and expertise in life sciences, such as microbiology, to be fully understood and analysed. In addition, some of the documents presented infographics and visual information, such as maps. For example, some of the yearly GLASS reports presented over a hundred pages long infographics for each of the countries that submitted their AMR data in that year. Although I have reviewed these infographics and maps, I have not analysed them separately and mostly relied on the textual information and WHO´s discourses describing such visuals through document coding.

The final list of the documents collected is presented in Appendix 3 which also includes an overview of what sections in each document was excluded due to the reasons outlined above. After the refinement of the document list, I proceeded with their analysis.

3.3.1.2. Document analysis

The document analysis stage in this thesis involved three rounds of document review, including the initial review of the documents, the first round of coding, and the second round of coding.

In the initial review of the documents, I familiarised myself with the document structure and read them without coding. During this stage, I have also noted any observable information about the document authors, where documents can be found, how long they are, and any other additional observations that

could further refine my research approach, including the research question and sensitizing concepts. Therefore, in this stage, I considered additional aspects related to the documents, namely: "how it is produced, how it functions in episodes of daily interaction, and how, exactly, it circulates" (Prior, 2007). Particularly in the STS field, as emphasised by Shankar et al, "scholars should be reluctant to separate the artifact (a text) from the practices (which are documented)" (2017, p. 59). However, it is important to note that such questions were not always visible in the documents or immediate online spaces where I found them as well as not always known by the interviewed stakeholders.

I then uploaded the documents to Atlas.ti software tool and coded them in two rounds. In the first round of coding, I started with an inductive approach (Rivas, 2018, p. 431), where I followed a broader research question and interest along the lines of understandings of global health, global health regime, and standardisation. After the first round of coding, broader categories and patterns have emerged as presented in Appendix 2 in this thesis.

Between the first and the second rounds of coding, I followed the zigzag approach (Rivas, 2018, pp. 432-433), meaning that the themes observed during my first round of document coding helped me to further refine and adjust my research question and approach which then also influenced the second round of coding and the refinement of themes stemming from the patterns observed in the documents.

Following the first round of document coding, in the second round, I looked for overarching themes that can connect emerging patterns and categories from the first round of coding (Rivas, 2018, p. 440). The emerging themes from the second round of coding then again helped me to refine my research question and research approach. As I first collected and analysed the documents, their analysis informed my interview approach as well, such as interview guides (Appendix 4) and provided me with a better understanding of WHO´s global AMR surveillance practices. After conducting interviews and analysing the material, I have triangulated my results with the document analysis as presented in the section below.

3.3.2. Interviews

To support and complement document analysis, I conducted four expert interviews. The purpose of these interviews was to interpret my collected material from the WHO document analysis and offer additional practical insights on AMR surveillance and GLASS implementation that are not mentioned in the documents. As suggested by Halkier (2017, p. 202), data production and analysis should rely on methods, where "the methodological design contains a mix of procedures that are aimed at getting to know the more tacit, embodied and material elements as well as the more explicit, discursive and conversational ones". While document analysis provides me with a more descriptive knowledge of AMR surveillance which is tailored to public access, interviews help me to reveal more practical knowledge of AMR surveillance practices as well as what stays behind the documents.

The interviewing process consisted of planning and conducting interviews as well as analysing the interview data. During the interview planning process, I have identified persons who could be interviewed as a part of this thesis research. The main source of the contact persons was provided by the GLASS documents as in their acknowledgement pages, they listed all contributors which, at some times, could reach 100 authors. I have aimed to contact persons to represent various WHO-defined regions as well as expertise (e.g., medical, epidemiological, regulatory, etc). Another source of potential interviewees came from my desk research on AMR surveillance and its different methods, where I have contacted authors of some of the publications that appeared to fit the research of this thesis. However, the list of interviewees in this thesis (Appendix 5) shows the inclination within the respondents to possess epidemiological expertise, and to be educated in and mostly to work within the European context.

While approaching potential interviewees, I introduced myself, the STS MA programme at the University of Vienna, my main research question, and why I have selected the expert for a potential interview. For more information, I have attached a one-pager presenting my research approach in more detail, together with my and the thesis supervisor´s contact details. Some of the approached experts did not respond to the interview request or outlined the reasons why they do not want to be interviewed. The main reasons for interview refusal were a high workload, family responsibilities or family leave, sick leave, or, as perceived by the respondents, a lack of understanding of global/local AMR surveillance systems and AMR data collection methods. With those experts who agreed to be interviewed, I proceeded with the agreement of the interview date and informed consent form.

Due to the course of the COVID-19 pandemic and the long distance to the interviewees that, at the time of the interview, were located in various European or Asian countries, I conducted interviews online via Zoom teleconference application. Before the interview, I sent respondents the informed consent form and the interview questionnaire, so they had sufficient time to familiarise themselves with the documents and to clarify any questions or comments before the interview as well as to obtain the respondents´ consent. In the informed consent form, I presented my thesis purpose, topic, and context of the thesis in line with the STS MA programme at the University of Vienna; how interview data is intended to be used, as well as emphasised the voluntary principle of participation and the right to retract the interview data use at any time before publishing the thesis (King, Horrocks & Brooks, 2019, pp. 37-38).

During the interviews, after the introductory part, I again explained an informed consent form to the interviewees and started recording our conversation with a Zoom recording function. Overall, all interviewees agreed to the informed consent conditions and either signed them directly in the informed consent sheet or agreed verbally, where the verbal agreement was recorded (Jensen & Laurie, 2016, p. 57). The interviews were conducted synchronously (James & Busher, 2012), meaning that I talked with the experts online in real-time. Interviews usually lasted from 40 minutes to more than an hour. The

length of the interviews depended on the prior agreement that the interviews are expected to last up to an hour (with a possibility to extend if the respondent is available). I have drawn such a time limitation as recommended by Harvey (2011) exploring specificities of expert interviews, where the interviewees usually dedicate from 45 minutes to an hour for interviews within their daily schedules.

During the interviews, I followed the interview guide as presented in Appendix 4. However, as the interviews were semi-structured, I often asked questions based on the answers provided by the interviewee aiming to expand and build on the respondent´s experiences and understandings. All interviews were conducted in English, and I transcribed the interview audio files verbatim. In the transcripts, I have not included the "non-verbal communicative behaviours" (Paulus, Lester & Dempster, 2016), such as laughing, hand gestures, longer pauses, and similar as, in my view, they did not change the meaning of the interview answers and did not impact the empirical material analysis.

During the interview data analysis phase, I analysed the interview data as a resource as well as the topic (Bryne, 2018, p. 222). On the resource side, I explored the contextual information provided about AMR surveillance, such as what are the common challenges, methods, and visions for AMR surveillance. As a topic, I also looked at how the interviewees talked about global and local AMR surveillance systems and practices, for instance, whether they were more supportive or critical of the WHO and their practices, what challenges in AMR surveillance they highlighted the most or emphasised as the most important, and how their answers corresponded to their different expertise of epidemiology, medical field, and health burden estimations.

Next to these considerations, I coded interviews in two rounds following the inductive coding approach (Rivas, 2018). As I have conducted interviews mainly after the document analysis, I have used the codes developed during the document coding. However, I have assigned additional codes to the interview material that emerged outside of the documents. I then refined the additional codes from the interviews that were not visible in the document coding to the categories and themes, and they informed the empirical parts of what is invisible in the publicly available WHO documents as well as what criticism and different views to the global AMR surveillance practices emerge.

After analysing codes, I also selected, in my view, the most representative quotes to inform the empirical analysis. In this thesis, I use pseudonymised quotes so that neither person's name, institutional affiliation or exact position title is disclosed in the analysis. I have also excluded the names of the countries mentioned by the interviewees after consulting one of the interviewees who emphasised that AMR surveillance is a rather narrow field and, especially in lower-income countries, there are only one or two persons in the whole country working in the AMR surveillance field, including AMR surveillance coordination. Therefore, I refer to the interviewees as "Interviewee I", "Interviewee II", "Interviewee III", and "Interviewee IV" in this thesis. One of the interviewees also requested to be presented in advance about which quotes are to be used in the thesis, as their expertise on AMR is quite

narrow and they do not want to be identified and recognised. After sending the list of the quotes to be used in the thesis, the interviewee agreed on their selection and presentation.

3.4. Methods of data analysis

After document and interview material collection and coding, I have looked at the emerging themes through the discourse analysis of the textual information. One of the ways that the discourses could be understood is through the meanings' constructions of discursive representations (Clarke, 2005) or discourse analysis. Discourse analysis is also broadly discussed by Foucault and as summarised by Hall (2001, p. 72) based on Foucault´s lectures, discourse "defines and produces the objects of our knowledge. It governs the way that a topic can be meaningfully talked about and reasoned about. It also influences how ideas are put into practice and used to regulate the conduct of others". Similarly, Hook (2001, pp. 42-43) outlines that "Discursive rules are hence strongly linked to the exercise of power: discourse itself is both constituted by, and ensures the reproduction of, the social system through forms of selection, exclusion, and domination". Exclusion of some practices from discourses are inevitable: "These processes, of formation and constraint, production and exclusion, are inseparable. More than this, they are both complementary and constitutive of one another; discourse is formed and exists through their mutual constitution" (Hook, 2001, p. 43). However, even dominant discourses can be challenged and resisted. As explored by Mohammed, Peter, Killackey, et al (2021, p. 3), the method of discourse analysis also explores "different practices of resistance or how people can challenge dominant constructions of the truth/untruth and knowledge authority". To this end, I also look at the GLASS through the lens of constructivism, where I see the assemblage of GLASS as constructed via numerous knowledge practices and navigation through embedded power relations by the WHO and other stakeholders involved (Andrews, 2012) in the global health field.

Particularly in the AMR field, through discourse analysis, AMR, its understandings, and the assemblage of global initiatives could be explored through the "scientific practices, policy guidelines, legal frameworks and regulations that AMR unfolds and exists within" (Antimicrobials in Society, 2017). Following the understandings outlined above, I looked at how the WHO constructs the meaning and understanding of the global initiative of GLASS as a global AMR surveillance system in its publicly available documents and how these meanings are accepted or resisted by others through the interviews of experts that work outside of GLASS while being closely familiar with its methodology and work. In addition, I looked at what discourses are more visible in the analysed documents and interviews and what discourses are not presented (in comparison to the views, criticism, and challenges outlined by the interviewees) or not as visible (for instance, alternative methods for AMR surveillance being presented at the annex of the GLASS report whose main body already consists of several hundreds of pages). Approaching AMR topic with discourse analysis was also used by Chandler (2019) who explored how AMR and its preparedness are stabilised via actuarial and sentinel devices (Lakoff, 2015a) while also looking at the publicly available discourses. Within the WHO documents and interviews, I particularly

looked at how the WHO constructs and maintains the discourses (Phillips & Hardy, 2002) that are a part of the broader understanding of global health, global health security regime, and standardisation as presented in the sections of State of the Art and Sensitizing concepts in this thesis while assembling the global AMR surveillance system – GLASS.

I have triangulated the collected themes from the documents and interviews, observing what are the most common emerging patterns. I have then also observed the differences between the themes, namely, what challenges or practices on global/local AMR surveillance do the interviewees mention that the publicly available documents by the WHO choose not to show or push to the annexes at the bottom of their public documents. Interviewees particularly opened up about the understanding and practices of AMR surveillance assemblage in the "local" settings. However, as outlined in the section below as well as in the State of the Art of this thesis, such accounts cannot be generalised as the understanding of "local" is much more complex, multiple and intertwined with the "global".

3.5. Limitations

This thesis provides insights into the assemblage of global by the WHO in assembling the global AMR surveillance system. These observations are based on document analysis and interviews. While both methods greatly informed this thesis, some of the limitations should also be mentioned.

Regarding document analysis, as specified in the chapter above, I have reviewed WHO documents on the GLASS. However, due to the high volume of GLASS documents, I might have missed other WHO documents on AMR and AMR surveillance that could have also potentially informed this thesis. One of the examples of such documents that were not included in the analysis is openly available National Action Plans (NAPs) by the WHO where national countries outline how they plan to implement GAP on AMR which also includes their plans on implementing global AMR surveillance in their national settings. Due to the high volume of NAPs, I could not review them as well as prioritise some countries' NAPs over others. In addition, some countries provide their NAPs solely in their native languages. However, further research efforts on AMR surveillance, their global assemblage and correspondence to the local settings could benefit from looking at NAPs and how countries discuss or understand global AMR surveillance in these documents.

For scoping reasons, I also do not engage with the WHO practices and GLASS modules on antibiotics consumption. The reasoning for this decision is that such activities only started in 2020 and WHO provides only a couple of documents about these GLASS activities. Although this thesis solely focuses on WHO´s practices in global AMR surveillance of bacteria, the WHO´s overall general discourse about antibiotic use and misuse is often presented as one of the key causes of AMR. Therefore, further research efforts on antibiotic use and its consumption surveillance could be carried out in line with the idea of WHO´s navigation within power relations in the global health field and exercising particular

knowledge practices in assembling the global surveillance system for antibiotics consumption, while also considering local practices and capabilities.

Although interviews were a valuable source of material that provided insights about what is missed in the WHO´s publicly available documents, further methods, such as an extensive ethnography, could reveal additional complexities in the field of global health and its initiatives, as well as their role in the local settings:

> "STS scholars have also argued we shouldn't take Global Health technology for granted, but should problematize it in terms of how the local and the global relate to and are reconfigured by each other. How do different actors talk about the local and the global and how are these discourses tied into specific practices? Answering these questions requires more than qualitative interviews as off-shoots of scientific projects; we would need detailed ethnographies of Global Health technologies and interventions across local and global sites over longer periods of time" (Sariola et al, 2017, p. 6).

For instance, Prussing (2020) conducted ethnographic research among epidemiologists that stem from the Indigenous communities in New Zealand and the United States that challenge and critically view the epidemiological expertise and the underlying epidemiological knowledge practices where some of them, historically, are based on colonialism. This ethnographic research shows that epidemiological expertise cannot be understood as a unit in itself but that it is also challenged and questioned by epidemiologists coming from different communities within. In addition, Williams (2018) explores power dynamics in ethnographic research itself, particularly conducted by researchers from the regions perceived as Global North in the Global South. To this end, Williams provides a framework on how ethnographer could reflect her or his position and provides a brief example of how, in some cases, the collection of epidemiological data from Global South can insert inequalities of how knowledge is presented "in the world-system" (2018, p. 214).

Overall, for this thesis analysis, I have conducted four interviews with different experts. Therefore, due to the scoping reasons, the understanding of "local" settings in this thesis is also generalised, given that different national countries, regions or even surveillance sites in hospitals can present different "local" experiences, concerns, expectations, and needs for (global) AMR surveillance. In addition, some of the limitations regarding interviews emerged not only due to the limited number of interviewees but also due to the common expertise that the interviewees shared. Interviews only included persons who can be regarded as "experts" in the global health field and (AMR) surveillance. Almost all experts were also trained in the epidemiology field which could shape their views towards AMR surveillance in a particular way. However, all interviewees showed reflexivity in their answers while talking about AMR surveillance and GLASS, especially while discussing challenges and aspects that could be done differently in AMR surveillance and/or GLASS.

This thesis also worked on the understanding of global and local and what is visible or invisible and where. However, as argued by Stephenson (2011, pp. 627-628), global and local cannot be understood as a simplified binary and it can be difficult to assign some of the actors only to a global or only to a local (e.g. epidemiologists who work in their national health ministries and assist or work with the WHO as well). In addition, the empirical part of this thesis does not engage with other stakeholders that might influence (global) AMR surveillance, such as pharmaceutical companies, NGOs, or complexities among governmental agencies and departments within local/national settings. Due to the scoping reasons, in this thesis, I focus on the stakeholders that are more visible in the WHO discourses, such as epidemiologists and clinicians. Due to the ethical complexities, I also do not engage with the patients´ perspectives on AMR surveillance, while patients´ or the publics´ perspectives are also not presented in the WHO´s discourses on AMR surveillance. To this end, this thesis only looks at the general components, such as the laboratory and/or healthcare infrastructures as well as the capabilities needed to conduct AMR surveillance, including their human and non-human components. Standardisation of bacteria and patient bodies to construct AMR surveillance and the relevant challenges are also not in-depth explored in this thesis due to the scoping and the methodological limitations. For instance, research exploring how human bodies are standardized in global clinical trials was carried out by Merz (2021) to make research results comparable. Based on the understanding of local biologies, global clinical trials can be based on the assumption that all bodies are universal, where the universality is usually drawn from the "Euro-American" body. To this end, such an understanding of universal bodies in the context of AMR surveillance standardisation and samples/AMR data collection could be a potential research topic for future endeavours.

Despite these limitations, this thesis and its discoveries about "local" acceptance of "global" AMR surveillance systems in the face of the WHO´s knowledge practices and navigation through embedded power relations in the global health field could provide directions for further research, for instance, in the topics of the competing "global" (AMR) surveillance visions and how they are assembled, competing views of experts within the WHO on (AMR) surveillance, case studies on specific local sites and how they implement or resist the "global" interventions, such as AMR surveillance, and others. These potential topics can be explored not only for the cases of AMR and surveillance but also for other global health initiatives and strategies assemblage, uncovering their underlying knowledge practices and embedded power relations in the global health field.

4. Theoretical perspectives

In this thesis, I combine and use understandings and theoretical perspectives of the global health regimes (Lakoff, 2017) and standardisation (Timmermans and Epstein, 2010), while answering the question of how is the "global" assembled through the knowledge practices and the navigation through embedded power relations in the global health field by the World Health Organization (WHO) through the implementation of the Global Antimicrobial Resistance and Use Surveillance System (GLASS). As these theoretical perspectives are rather broad, in this thesis, I also refer to the concepts of actuarial and sentinel devices (Lakoff, 2015a) as well as global assemblages (e.g., Collier, 2006).

4.1. Complexities of the global health field: global assemblages and global health regimes

As already hinted in the State-of-the-Art section, the global health field can be a "messy hybrid" (Montgomery et al, 2017, p. 6), where different entanglements between the global and the local, including the "geographical, political, institutional and sectorial boundaries" (2017, p. 3) intertwine and can even resist each other. Within this complexity, the global health field can be investigated through the lenses of global health assemblages (e.g. Collier, 2006) and global health regimes.

Some theoretical perspectives view the global as being constantly assembled. Collier (2006, p. 400) defines global assemblage as "the actual configurations through which global forms of techno-science, economic rationalism, and other expert systems gain significance". Collier distinguishes the understanding of global assemblage from the understandings of the global and local as "it should be clear that the global assemblage is an alternative to the categories of local and global, which serve to cast the global as abstraction, and the local in terms of specificity" (2006, p. 400). The global assemblage can also be a tool to assemble global knowledge "taken in the double sense of knowledge about global forms and knowledge that strives to replace space, culture, and society-bound categories that have dominated the social sciences throughout their history" (2006, p. 400). In an interview with Saskia Sassen (Aneesh, 2017, p. 129), global assemblage is also explored as "a working category, a tool, not only an outcome, a result", hinting that global assemblage is a continuous process. In this interview, Sassen and Aneesh explore what is particularly left out while assembling the "global", namely "What don't I see when I focus on the strong centre of the paradigm" (2017, p. 129) and what underlying power relations in the global health field shape these processes, such as what is more visible and what is left invisible.

However, the assemblage of "global" cannot be solely understood as a top-down approach. For example, Rubin (2019) refers to the combination of global and local as "glocalization". Rubin explains that glocalization "acknowledges that global processes are not happening against or outside local forces; on the contrary, both global and local are mutually constituent concepts. Glocal governance, therefore,

suggests that global challenges should be addressed by the effective reconciliation of the local and the global" (2019, p. 2). This includes not only the involvement of numerous local actors but also including different health sectors "including human and animal health, food production, environment, water and sanitation, education and trade".

The points within the global assemblage of global knowledge, underlying power relations, a continuous process of assembling, and entanglement of global and local are also present in Lakoff´s (2017) perspective of two regimes of global health: global health security and humanitarian biomedicine. One of these regimes – global health security – aims to prepare for events that might produce negative outcomes on policy, economic, or health levels. This preparation corresponds to the "pathogenic imaginary" which envisions an emergency of infectious and deadly diseases spreading around the globe (Lakoff, 2015b). To this end, the global health security regime aims to prepare for such threats. To help this preparedness, global surveillance systems emerge that "can provide early warning of potential outbreaks and link such early warning systems of rapid response designed to protect against their spread to the rest of the world" (Lakoff, 2017, p. 72). To implement global surveillance, these systems must be connected, while including and excluding what to measure and how, and where specific knowledge is created informing a particular response towards AMR.

Various forms of global health security regimes have existed and changed in the last centuries while involving different international or global actors. Hoffman (2010) explores the evolution of the global health security regime. Hoffman distinguishes four stages of global health security regime, namely: "unilateral quarantine regulations", "multiple sanitary conferences", "international sanitary conventions and international health organizations", and "leadership of the World Health Organization" (p. 510). The global health security regime could be argued to be starting with "the invocation of unilateral quarantine regulations by many European ports and extends back to the bubonic plague of the 14th century" (Hoffman, 2010, p. 511), followed by the "international dialogue and security harmonization via a series of International Sanitary Conferences" encouraged by the cholera outbreaks in the 19th century, while, starting with the 20th century, new institutions emerged, such as the "Pan-American Sanitary Bureau (1902), Office International d'Hygiene Publique (1907) and the League of Nations' Health Organization (1923)", with the WHO emerging after the Second World War (p. 512). As Hoffman argues, the "WHO has become a global hub for health security—albeit with questionable moral authority and effectiveness", particularly because "WHO lacks the authority and resources commensurate with its vast responsibilities. (p. 514).

The most recent stage of the global health security regime appears to increasingly rely on virtual spaces and developing technologies for fast health data monitoring. For instance, Weir (2012) also provides a genealogy of global health security and focuses on the role of the WHO and particularly the evolvement of technologies that enable real-time surveillance data monitoring in virtual spaces. For example, corresponding to infectious diseases, the WHO established "the Division of Emerging and Other

Communicable Diseases Surveillance and Control" and "a system of outbreak detection and control called the "world on alert"". The main goal of the "world on alert included communicable diseases containment through a global monitoring network, electronic information exchanges, national and international preparedness, rapid response, and national surveillance and control" (Weir, 2012, p. 323). Particularly with the emergence of the internet, such information could be monitored online, as it is currently carried out by the Global Public Health Intelligence Network (GPHIN) which is a part of the WHO´s Global Outbreak Alert and Response Network. Health data can be collected in "real-time" and at any time as: "The "real-time" operation of global health security enables local historical events to be inserted in the continuous globalized time of digitally mediated public health knowledge" (2012, p. 325). This shows that the global health security regime particularly draws from surveillance and relevant technology that can collect and aggregate different health data globally.

At the same time, the global health security regime shows a clear divide between the "global North" and the "global South" (Lakoff, 2017). The understanding of the global security regime highlights the efforts to establish a laboratory and other relevant infrastructures, especially for infectious disease detection and monitoring, especially in the "global South". For instance, some research points out that further funding could help to enhance surveillance efforts by investing in laboratory infrastructures (e.g., Ashley et al, 2019), especially in the regions that are perceived as lower income. However, high-income countries "with excellent regulatory capacity" also often experience challenges when implementing global solutions in more local settings, such as "implementing effective policies due to lack of political will, prevailing ideologies, and interference by vested economic interests" (Magnusson & Patterson, 2021, p. 473).

Drawing on increasing technological capabilities, global health security can be quantified and measured. For instance, Mahajan (2021) explored the Global Health Security Index. This index involves "indicators about laboratory systems, real-time surveillance, response planning, risk communications and plans for trade-and-travel restrictions" (2021, p. 207). Therefore, to measure such indicators, national countries are expected to possess laboratory infrastructures and surveillance systems to sufficiently plan, communicate, and respond to potential global health threats. Therefore, data collection is increasingly used as a form of expertise for decision-making. As explored by Merry (2011, p. 83), the

> "turn to indicators in the field of global governance introduces a new form of knowledge production with implications for relations of power between rich and poor nations and between governments and civil society. The deployment of statistical measures tends to replace political debate with technical expertise".

The use of data gathered is presented by policymakers as "objective" or "scientific", meanwhile Merry also argues that although data collectors announce what they measure, "such as "rule of law" or

"poverty." Neither of these categories is self-evident" (2011, p. 84). To this end, "Indicators are a technology of not only knowledge production but also governance". Especially in the case of "global" indicators and data collection, "an increasing reliance on indicators tends to locate decision making in the global North, where indicators are typically designed and labelled" (2011, p. 85). Therefore, "indicators are inevitably political, rooted in particular conceptions of problems and theories of responsibility. They represent the perspectives and frameworks of those who produce them, as well as their political and financial power. What gets counted depends on which groups and organizations can afford to count" (2011, p. 88). However, global indicators can translate differently in local settings, where "Local centers may understand the process differently, carry out the measurement tasks in different ways, or resist cooperating with national and international expectations" (2011, p. 89).

In comparison, while the global health security regime draws on the self-protection of countries, humanitarian biomedicine takes an ethical stance on common humanity (Lakoff, 2017, p. 73). This regime particularly focuses on "diseases such as malaria and tuberculosis (TB) that currently afflict large numbers of people in places where treatment is difficult or impossible to access. The objective of humanitarian biomedicine is to alleviate the suffering of individuals, independent of national and social identity. Such intervention is seen as necessary in settings where public health infrastructure has broken down or is nonexistent". In addition, as a "social and technical project, this regime of global health seeks to bring advanced diagnostic and pharmaceutical interventions to those in need" (Lakoff, 2017, p. 72).

The understandings of global health regimes also correspond to the concepts of actuarial and sentinel devices by Lakoff (2015a). The actuarial devices are based on the mapping of "disease over time and across populations to gauge and mitigate risk", while sentinel devices "treat unprecedented diseases that cannot be mapped over time but can only be anticipated and prepared for" (Lakoff, 2015a, p. 40). In the case of AMR, the surveillance of (global) AMR data could be best understood as an actuarial device (Chandler, 2019, pp. 3-4). In the case of the GLASS, the platform often refers to the experiences and methodologies of older AMR and other drug resistance surveillance systems, namely ReLAVRA+, EARS-Net, surveillance of HIV drug resistance, surveillance of resistance to anti-tuberculosis drugs, and surveillance of antimalarial drug efficacy. Similar to these systems, the GLASS-AMR module aims to collect data over time and across populations from countries' national AMR surveillance systems to fill in the knowledge gaps and inform policies and strategies at all levels. In addition, such activities could also be viewed through the lens of humanitarian biomedicine as often they also involve or are based on existing drug resistance and the potential to create newer and more effective drugs, such as antibiotics. At the same time, the rationale for establishing (global) AMR surveillance can be understood via the sentinel devices, such as calculating and projecting negative AMR outcomes in the future and carving out the gap for the need for global AMR surveillance.

To this end, I consider that the understanding of global assemblages and global health regimes could help me to understand how the WHO assembles the GLASS as a global AMR surveillance system by looking at what discourses the WHO use in its efforts that also correspond with the understanding of the global health regime. Such discourses could relate to national/regional security, the division between the "global North" and the "global South", and the promotion of surveillance technologies, such as laboratories and laboratory testing methods, in different regions, particularly the ones considered to be in the "global South", and saving lives or helping regions and countries considered as "lower-income". Global health regimes (Lakoff, 2017) of global health security and humanitarian biomedicine are broader paradigms that shape how AMR is thought about, enacted, and what solutions are envisioned to solve AMR on a global scale. While global health security emphasises national security concerns and surveillance, humanitarian biomedicine highlights the need to save lives, particularly in countries and regions perceived as lower-income and for this, the envisioned solutions are medical interventions, such as the development of medicines or vaccines. In the case of assembling GLASS, different modules to varying extents embrace either of the global health regimes. In addition, the understanding of global assemblage is helpful to explore the entanglement of global and local elements in AMR data collection practices as well as what remains in the centre and what is left out from the more visible discourses.

4.2. Standardisation

The understanding of standardisation makes complex processes easier to implement on different levels, such as globally and locally. The work of Timmermans and Epstein (2010, p. 74) offers conceptual tools to study standards. They divided the standardisation practices into the "phases of creation, implementation and resistance, and outcomes", however, it should be kept in mind that these phases do not necessarily have cut boundaries. In the beginning, standards are usually set up collectively, however, some actors still might need to be convinced of their creation and implementation (Timmermans & Epstein, 2010, p. 75). Usually, some coordinating organisations "call for the creation of a standard, invite partners to collaborate on the standard, and then depend on the standardizing organization to distribute the standard" (Timmermans & Epstein, 2010, p. 77). While the standards are usually created for the public interests, the public usually does not directly participate in their creation, while some activist groups can present a stronger resistance at that phase.

For the standardisation process to work, not everything can be standardised, meaning that some things can be excluded while others are included. Busch (2013, pp. 12-13) states that "as standards are used, people and things are tested, and we determine what shall count. Those people and things that pass the tests or make the grade are drawn into various networks. In contrast, those persons and things that fail the tests do not count; they do not make the grade". Therefore, the standardisation process includes knowledge practices and embedded power relations by determining what counts and what does not, and why or why now. To this end, Turnhout, Neves, and de Lijster (2014) emphasise that "measuring can

never be a completely neutral activity. It involves the exercise of power in the sense that rendering an object of interest measurable or legible (Scott, 1998) involves critical choices about what to measure and how". If standardisation practices intend to create some sort of knowledge, these choices then render some aspects invisible or not known. Non-knowledge is also political, namely who has the authority to know, what is to be known and how (Böschen, Kastenhofer, Rust, et al. 2010). However, these choices, including the standardisation practices, may remain invisible from the public eye: whose knowledge and experience (scientific, political, etc) are taken into consideration and how these choices were made.

Standard implementation often follows a top-to-bottom approach and includes a variety of different expertise and knowledge practices. In the standard implementation stage, a variety of stakeholders or an "army of technicians, auditors, monitors, and consultants exist to implement and evaluate standards" (Timmermans & Epstein, 2010, p. 80). These different practices and experts need to implement the standards in line with the local work practices, institutions, infrastructures, and technologies: "Depending on the standard, building standard-based societies may require integration on many different levels: from national cultures with their moral orders to institutions with their conventions of work practices, organizations, and multiple layers of technologies." (Timmermans & Epstein, 2010, p. 81). During the standards implementation stage, a technological zone is aimed to be created, namely: "a space within which differences between technical practices, procedures or forms have been reduced, or common standards have been established" (Barry, 2006, p. 239). Once standards are established, they are supposed to achieve "some small or large transformation of an existing social order" (2010, p. 83). However, the standardisation practices can make it difficult to observe the local capabilities and knowledge practices that might have been different than the standardisation process initially expected:

> "Once standards are established, they render invisible the work required to make them possible and the uncertainty and ad hoc tinkering that accompanied standard implementation. The power of standardisation lies exactly in how such local erasure allows new manipulations to take places such as calculation and commodification." (2010, p. 83)

Despite this largely top to bottom approach, standards can also be resisted by the local structures. Therefore, some form of flexibility could be a key to standardisation success as well as trust in the local practices and capabilities: "The trick in standardisation appears to be to find a balance between flexibility and rigidity and to trust users with the right amount of agency to keep a standard sufficiently uniform for the task at hand" (Timmermans & Epstein, 2010, p. 81).

Lastly, while studying standardisation processes, Timmermans and Epstein (2010, p. 85) encourage us not only to study how standards organized social life but also how things could have been done differently. Although this thesis does not intend to provide solutions of how the WHO could assemble the GLASS standardisation and global implementation differently or what possible knowledge could

be derived from GLASS data, this work gives some space and considerations for other views, especially those that come from outside of the WHO and more considerations for local contexts and their practices that could be made invisible in the publicly available WHO discourses. In some cases, other stakeholders' views can challenge the currently envisioned WHO practices that assemble GLASS as a global AMR surveillance system via different standardisation practices.

To this end, I suggest using the understanding of standardisation in this thesis to better understand the WHO´s knowledge practices and its navigation of embedded power relations in the global health field while assembling GLASS. WHO´s efforts include the standardisation of currently existing local AMR surveillance systems or building AMR surveillance systems from scratch in regions where they are not available according to the already established standard. I intend to follow Timmermans and Epstein´s (2010) "phases of creation, implementation and resistance, and outcomes" and the relevant aspects that such phases entail while looking at how WHO assembles GLASS. They show that GLASS is created through standards as well as how it functions despite the lack of or resistance towards standardisation.

Overall, to assemble the Global AMR Surveillance System (GLASS), the WHO needs to navigate the standardisation of currently existing AMR surveillance systems as well as convince stakeholders to build AMR surveillance systems according to the WHO methodology, if such systems do not exist in national or regional levels. Therefore, the WHO assembles GLASS via standardisation efforts. These efforts include the WHO´s endeavours to navigate complex power relations between different stakeholders in the global health field as well as different expertise and knowledge of how the GLASS should be assembled as a global surveillance system. The standardisation practices of the GLASS-enabled surveillance allow seeing what is visible and prioritized in a global assemblage, for instance, which stakeholders, expertise, and data collection practices. Similarly, the standardisation practices of the WHO also allow exploring further what is left out of the global assemblage of the GLASS, for instance, what stakeholders, expertise, or data collection practices.

5. Empirical analysis

5.1. Navigating the embedded power relations in the global health field while assembling global AMR surveillance

5.1.1. WHO assembling AMR as a global health threat: global health security regime

5.1.1.1. AMR as a global health threat

The WHO reinforces itself as a global AMR surveillance coordinator mainly by emphasising AMR as a global health threat. The WHO documents shape the threat of AMR as a global issue. WHO experts present reviews saying that some countries, mainly higher-income countries from Europe and North America, have already implemented measures to counter AMR or started to rapidly prioritise the development of AMR countermeasures (World Health Organization, 2017a, p. 3). However, the WHO presents the AMR issue not only on the country/region level but also reinforces it as a global issue:

> "There is growing concern about the impact of AMR on health and on entire societies and growing appreciation of the complex global and multisectoral aspects of the problem." (World Health Organization, 2017a, p. 3).

For AMR negative effects to be truly understood on a global level, WHO often compares AMR to other past global crises and as a threat. In the WHO and GLASS 2nd High-Level Technical Meeting on Surveillance of AMR for local and global action in 2017, the Swedish State Secretary for Foreign Affairs Annika Söder not only emphasised AMR as a global security threat but also compared it with climate change and a financial crisis of 2008:

> "It had been estimated that unless AMR were controlled, by 2050, it would cause economic damage comparable to that due to the economic crisis of 2008. AMR was recognized as a security issue in Sweden, as part of the national security plan and had been identified by the Swedish public as a threat on a par with that of climate change." (World Health Organization, 2017a, p. 4).

However, the document does not provide further details on how AMR effects are projected to achieve these negative outcomes by 2050 nor how the Swedish public came to an agreement that the potential AMR effects are to be compared with the outcomes of climate change or financial crisis. Future projections of negative health and economic impacts of AMR effects remain a recurring theme in GLASS documents since its establishment in 2015. These negative outcomes, if AMR remains unaddressed, are mostly presented to be economic, next to the negative health benefits, and they gain a global dimension in the later WHO documents:

> "It is estimated that, by 2030, AMR infections resulting in increased morbidity, disability, premature deaths and reduced effective labour will become a significant threat to the global economy if action is not taken" (World Health Organization, 2020b, p. viii).

Although reference to such a claim is provided in the document, it is unclear now how the document´s authors projected such conclusions from the database as no clarifications are provided. The above examples also highly refer to the estimations and predictions made in the future that depict the negative effects on the economy and health if urgent action is not taken in the present.

Later WHO documents continue to compare and present AMR in line with other global crises, such as the COVID-19 pandemic. Documents used the COVID-19 pandemic to emphasise the importance of AMR surveillance as a tool to prepare for AMR future threats, especially referring to global health crises:

> "The COVID-19 experience has shown that surveillance systems are crucial for the detection and management of new public health threats. Antimicrobial resistance (AMR) is an example of such an emerging threat with permanent humanitarian and economic consequences if not tackled aggressively" (World Health Organization, 2020a, p. iv).

In addition, in more recent WHO documents, AMR is presented as not only needing to be addressed more urgently but also more aggressively, while taking more drastic measures. The latest WHO documents on GLASS continue present AMR not only as a global health threat but also as a global security threat, including the AMR being a threat to livestock, food security and sustainable food production (World Health Organization, 2020b, p. viii). If unaddressed, WHO views AMR as hindering the achievement of the United Nation's sustainable development goals (World Health Organization, 2020b, p. viii; World Health Organization, 2020c, p. 1). Documents highlight that AMR threatens the achievement of the second, third, and eight sustainable development goals (SDGs) related to food security, human health and well-being, and economic growth:

> "A reduction in the frequency of bloodstream infections due to methicillin-resistant Staphylococcus aureus (MRSA) and Escherichia coli resistant to third-generation cephalosporins has been proposed as an indicator of progress towards SDG 3, "Ensure healthy lives and promote well-being for all at all ages" (1). Moreover, AMR infections in livestock endanger sustainable food production and food security (SDG 2: Zero hunger, and SDG 8: Decent work and economic growth) (5)" (World Health Organization, 2020b, p. viii).

To tackle the AMR threat to the UN's sustainable development goals, the WHO suggested introducing some changes to the SDGs, aiming to address and reflect the threat of AMR to them:

> "(…) upon the request of Member States, WHO proposed the inclusion of a new AMR indicator linked to target 3.D ("strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks") in the monitoring framework of the Sustainable Development Goals (SDGs). This indicator monitors the proportion of BSIs (bloodstream infections) due to Escherichia coli resistant to 3rd generation cephalosporins and methicillin-resistant Staphylococcus aureus (MRSA) (6)" (World Health Organization, 2021a, p. 2)

These suggested changes correspond to the WHO´s Work Programme of 2019-2023 which added the monitoring of pathogens in bloodstream infections and global antibiotic consumption.

Despite the high-level external support and its previous experience with AMR, the WHO continues to emphasise its work in the field through the AMR threat, while comparing it to other global threats, such as climate change or financial crisis as well as reminding of the WHO´s expertise during the global health crises with one of the most prominent and recent examples being the COVID-19 pandemic. During the COVID-19 pandemic, the WHO has been known for its surveillance efforts, where data was mainly aggregated by the WHO from the national countries. Therefore, the COVID-19 pandemic is one of the arguments why AMR surveillance could be key in managing the threat while monitoring the situation of resistant pathogens and where they are more common. The threat of AMR is also shaped as a global security threat that impacts not only human health but it can also threaten food security, farming and livestock that involve the practices of antibiotic use, and economic growth. Here, the WHO aligns with the United Nation´s Sustainable Development Goals, including its visions of the global AMR surveillance implementation and what should be counted and where (particular pathogens selected for bloodstream infections). Therefore, dealing with AMR as a global health threat is necessary to maintain global health security, where preparedness is key.

5.1.1.2. Preparedness for global AMR health threat

To this end, preparedness is an important tool for the WHO to convince countries of the need for AMR surveillance systems as well as for the GLASS. WHO documents released right after GLASS establishment emphasised various benefits if countries joined AMR surveillance efforts. Such advantages mainly involved the economic benefits of AMR surveillance. Although it is difficult to calculate the exact benefits of AMR surveillance, WHO documents still assume positive benefits drawn from the "preparedness" for AMR threat as well as the losses when preparedness is not enacted:

> "A major economic benefit of surveillance is preparedness, which is frequently overlooked because the cost of lack of preparedness is difficult to estimate. It has been estimated that a complete lack of preparedness for AMR between now and 2030 would increase extra health care expenditure to US$ 0.22 trillion annually, even in a setting

> with low AMR (2). Good surveillance can help health systems to prevent major outbreaks of AMR pathogens and to be prepared if they do occur." (World Health Organization, 2020b, p. 14).

Therefore, AMR surveillance can prevent a lack of preparedness that experts estimate to cost countries trillions of dollars annually. Based on such similar evidence, the WHO assumes that investing in AMR surveillance is "one of the highest-yield investments a country can make to mitigate its impact" to secure itself against the dire consequences that AMR is projected to cause in the future (World Health Organization, 2018a, p. v). However, similar to the predictions about the negative effects of AMR that are counted for the future and that involve losses for the (global) economy and human health, the benefits of AMR surveillance are also shown as the avoidance of costs caused by the lack of preparedness for AMR. To this end, one of the tools of preparedness for AMR is the global AMR surveillance system, such as GLASS.

Following these discussions about AMR threat, WHO incorporates AMR threat directly into one of the GLASS modules, namely the GLASS Emerging Antimicrobial Resistance Reporting (GLASS-EAR). Within the GLASS Emerging Antimicrobial Resistance Reporting (GLASS-EAR) module, countries can submit AMR data that seems rare or that potentially can cause an emergency in local as well as global settings. It was established in 2018 "at the request of Member States to support the detection, early warning and risk assessment capacities of national AMR surveillance programmes" (World Health Organization, 2017c, p. 4). Unlike AMR data collected yearly, GLASS EAR is supposed to facilitate and encourage countries to quickly submit any AMR-related cases that seem like an emergency based on samples not only from humans but also from animals and the environment. Participants of the GLASS Collaboration Platform meeting in Copenhagen in 2015 agreed on the need for the GLASS-EAR module based on the rationale to "signal emerging AMR mechanisms and map their global spread" (World Health Organization, 2018c, p. 7). Some positive examples mentioned from the GLASS-EAR practice were the "detection of Candida Auris for the first time in Thailand, data on multidrug-resistant (MDR) Salmonella Typhi, and new ceftazidime‑avibactam resistance" (World Health Organization, 2019, p. 13). The detection of these pathogens was mentioned as a positive example because the appropriate measures were taken in time to stop the pathogen spread and it was envisioned that broader negative health and economic effects were avoided.

Although the GLASS-EAR module emphasises quickness and emergency, while the emergency AMR observations are encouraged to be reported to the WHO within two weeks of their discovery, submission of data to the GLASS-EAR module is also voluntary. GLASS-EAR module on Emerging Antimicrobial Resistance Reporting "implements a workflow process for notifying a diverse range of stakeholders on a timely basis and in compliance with agreements such as the International Health Regulations" (World Health Organization, 2022a). However, such voluntary reporting of emerging AMR data presents challenges. Countries are not legally obligated to submit AMR data, while a voluntary principle for

submitting AMR data can cause tensions. Unusual AMR data can also be withheld for personal profit. For example, there is “an inherent tension in reporting new AMR and withholding information for later publication purposes. To address this, journals should be encouraged to consider AMR as a public health threat and recognize reporting to GLASS of a new AMR as a citable event” (World Health Organization, 2016b, p. 13). However, there is no information on whether any journals implemented such encouragement for researchers to report new AMR cases to the WHO instead of writing a publication about it first. To this end, in 2020, only nine AMR emerging events were reported to the GLASS and they mostly came from the WHO studies and rarely from the national countries and their reporting (World Health Organization, 2021a, p. 44).

Concerns that national countries would not report to the GLASS-EAR were already expressed in the WHO meetings in 2017 as well. At the Second High-Level Technical Meeting on Surveillance of AMR for local and global action, participants shared that such AMR reporting systems for emergency cases are rarely used. For instance, in Europe, the Epidemic Intelligence Information System (EPIS) “had rarely been used for AMR“, while “considering also that IHR channels were already available as an early warning system“ for AMR (World Health Organization, 2017a, p. 10). Another issue was that different countries understand the notion of emergency differently. What could be classified as a rare or emergency AMR case in Europe, might be quite common in other regions, for instance, in Southeast Asia, and would also not be classified as an emergency globally.

Overall, the GLASS-EAR module shows WHO's efforts to not only collect yearly AMR data and promote the standardisation of laboratory infrastructures but also to collect and correspond to emerging AMR cases quickly. However, although GLASS-EAR provides an opportunity for countries to submit unusual AMR observations at any time, it is still rarely used by the national countries and other stakeholders outside the WHO. This could be explained by the observations that such emergency AMR reporting is voluntary as the WHO does not have a legal framework to enforce such data submission on a global level. Also, unusual findings about AMR could provide a basis for academic publications and career advancement first. In addition, there is a lack of understanding and agreement on what is an emergency AMR case, particularly on the global level and whether it is worth to be reported. GLASS-EAR and WHO´s efforts also overlap with other existing systems, such as EPIS in Europe and IHR channels that collect the same information. Although WHO´s documents reflect these challenges, WHO still promotes the GLASS-EAR system as a part of GLASS surveillance. WHO´s documents perceive it more as a complimentary system to the yearly routine AMR surveillance and justify the system as a request of WHO member states, even though, in the end, the same countries who are supposedly requested such a system do not submit such local AMR emergency data to the GLASS or a global level.

5.1.2 WHO roles in the global AMR data collection and standardisation: WHO as a global coordinator and collaborator in the global health field

The empirical material analysed for this thesis emphasised the central role of the World Health Organization (WHO) in assembling and coordinating AMR solutions globally, including the global AMR surveillance conducted by the GLASS. However, the WHO needs to navigate a variety of power dynamics in the global health field while assembling GLASS. The organization assembles GLASS in the ways of top to bottom (coordination) and bottom-up (collaboration) among the different actors in the global health field, such as high-level political figures, individual countries, (international) organizations, experts, and other initiatives.

The WHO´s coordinator role for the AMR solutions, including GLASS, is supported by numerous high-level political figures, WHO´s expertise on AMR and surveillance overall, countries, and international organizations. Following the external reinforcements and own previous experiences, the WHO reaffirms its role as AMR response coordinator in the global health field, while setting up its work agenda and including AMR response coordination to the GLASS. In this way, the WHO assembles GLASS as a global coordinator and in a top-down approach, while assigning which stakeholders are to be involved in global AMR surveillance efforts in the local settings.

Attention towards AMR particularly gained momentum around 2015 on a higher political level. One of the most prominent examples is the political figure of Dame Sally Davies – a former Chief Medical Officer in the United Kingdom. One of the interviewees argued that she was the key person in influencing the recognition of AMR not only in the UK but also globally, including in the WHO:

> "…if you go back a bit in a history of how AMR (…) got such kind of high prominence globally, I think UK government really managed to get a lot of attention. So even though other European countries have been focused on it for a long time, there is the chief medical officer of the UK who is called Sally Davies, she still has a high profile on AMR, she really took it to the WHO and helped to get it, you know, so much prominence. As the result, the government of the UK decided to put a lot of money behind that. So, I believe, they put 200 million pounds into this" (Interviewee III).

However, although AMR has not been as prominent in the global health field before the mid-2010s, it was also not a new topic in the WHO. In its documents that have been released in the mid-2010s, the WHO repeatedly reminds its past role and experience collected in tackling the global AMR threat. Some documents state that the WHO recognised and started working on AMR 20 years ago (around the early 2000s) which then culminated in the Global Action Plan released in May 2015 by the 68th World Health Assembly. Before that, in 2001, WHO released the Global strategy for the containment of AMR, followed by the World Health Assembly resolution WHA58.27 on improving the containment of AMR

in 2005; and presented the AMR issue in the 2011 World Health Day policy package (World Health Organization, 2014, p. 71). To this end, the WHO positions itself as a leader in the action against AMR:

> "WHO has been leading the response to AMR over the past two decades and its efforts led to the approval of the Global Action Plan on Antimicrobial Resistance (GAP-AMR) by the Sixty-eighth World Health Assembly in May 2015 (4)" (World Health Organization, 2021a, p. 2).

Once the GAP on AMR was approved, it was viewed by the WHO as one of the most important milestones in addressing the AMR threat globally. In 2016, GLASS Secretariat member Dr Marcus Sprenger stated:

> "20 years ago this topic was being discussed but with little progress achieved until very recently. The United Nations General Assembly high-level meeting in September 2016 and the commitment of all Member States to tackle AMR was a milestone. AMR has now become an issue for Heads of State who recognize its implications for trade, agriculture, education, health and the environment." (World Health Organization, 2016b, p. 13).

WHO and GLASS also draw experience from earlier infectious diseases surveillance networks that focus on drug or pathogen resistance. WHO's global surveillance networks for diseases, such as HIV, influenza, malaria, and tuberculosis emerged before the GLASS and looked into specific pathogens that become resistant to available drugs (World Health Organization, 2018a, p. 2). For instance, WHO already conducted surveillance of the resistance of pathogens of the *Mycobacterium tuberculosis* for tuberculosis and *Neisseria gonorrhoeae* for gonorrhoea before the establishment of the GLASS (World Health Organization, 2015b, p. 1). To this end, the WHO shaped the AMR surveillance along the lines of other diseases surveillance networks "based on defined populations and epidemiological samples", where the lessons "can be learnt from these programmes, and there may be opportunities for synergies from collaboration, although such solutions are not entirely transferable to surveillance of common bacteria" (World Health Organization, 2014, p. 70). Therefore, GLASS is also presented as filling in the gap because the current non-AMR surveillance systems do not collect more data on resistant bacteria in humans (World Health Organization, 2015c, p. 8). Here, the WHO carves itself a role in global AMR surveillance standardisation and coordination.

The question might emerge why others have to follow the methodologies for AMR surveillance implied by the WHO as global. This comes mostly from the national country governments and their connection with the WHO. The WHO documents state that its work on tackling AMR was delegated by the countries' governments. One of the WHO reports emphasises that all countries unanimously recognised the AMR threat and voted positively for a global action plan which should help to tackle AMR globally: "WHO Member States recognized this threat by unanimously approving a global action plan to tackle

AMR at the Sixty-eighth World Health Assembly (resolution WHA68.7)" (World Health Organization, 2020a, p. viii). Documents depict that the WHO member states themselves requested the global AMR surveillance to "(…) develop and implement an integrated global programme for surveillance of antimicrobial resistance across all sectors in line with the global action plan" (World Health Organization, 2015c, p. 8). However, there is no list of countries that have requested the WHO to implement global AMR surveillance, unless we count the WHO member countries who agreed on the Global Action Plan on AMR which includes the objective of global surveillance implementation. Other international organizations, such as the United Nations also reinforced the WHO's position in dealing with the AMR threat. In 2016, "the Political Declaration of the UN High-level Meeting on Antimicrobial Resistance (Resolution A/RES/71/3) emphasised the "grave challenge of AMR", the need for One Health approach to tackle AMR, and viewed Global Action Plan on AMR by the WHA as a "blueprint for tackling AMR" as well as the need for AMR surveillance led by the WHO (World Health Organization, 2017a, p. 3). Therefore, WHO sees its endeavours towards AMR, including GLASS, as requested by the national countries as well as reinforced by other international organizations, such as the WHO.

WHO also continued reaffirming its role in AMR and global AMR surveillance implementation internally. In 2016, the WHO appointed Dr Hajime Inoue to be an Assistant Director-General for the WHO Special Representative for Antimicrobial Resistance. In one of the WHO documents, Dr Inoue was recorded to emphasise the central role of the WHO in fighting the AMR and advised the WHO to prioritise GLASS in this fight as it can ensure "good evidence" (World Health Organization, 2016a, p. 16) through the standardisation of global AMR data collection and surveillance systems. In 2018, the 71st World Health Assembly again brought the AMR topic to the agenda with the event "Addressing Antimicrobial Resistance: A Threat to Global Health and the Achievement of Universal Health Coverage". The event again emphasised the importance of AMR surveillance for informed policymaking and regulated use of antibiotics (World Health Organization, 2018a, p. 2). The WHO continues integrating AMR into its working programme. The WHO's 13th General Programme of Work (2019–2023) added two specific AMR indicators for measuring WHO's work: "(i) bloodstream infections due to two specific pathogens and (ii) trends in national consumption of antibiotics" (World Health Organization, 2020a, p. 2). These indicators mean that overall WHO´s work effectiveness will be measured by how well it implemented the programmes towards AMR in bloodstream infections as well as measured the global consumption of antibiotics. Therefore, both of these indicators have been translated directly into the GLASS activities, namely, what needs to be counted. GLASS now gathers surveillance data on these two pathogens in bloodstream infections: *E. coli* which can cause stomach cramps, diarrhoea, vomiting, and fever, and *Staphylococcus aureus* which can cause skin infections, pneumonia, meningitis, or sepsis. GLASS also plans to collect national antibiotic consumption data and has started some initial calculations since 2020. These indicators have been presented as requested to

be included by the member states of the WHO as well as proposed based on consultations with the experts and the public (World Health Organization, 2020a, p. 2), although, it is not clear which countries or public(s) have requested the WHO to calculate these pathogens and antibiotic consumption and how.

While receiving external validation as a global AMR solutions coordinator, including AMR surveillance, WHO drew boundaries on who should be involved in standardising AMR surveillance in a top-down way. Early GLASS reports have presented some boundaries of who the intended readers are that could hint towards the stakeholders that are intended to be involved in the (global) AMR surveillance and GLASS. In 2014, the WHO Global Report on AMR surveillance clearly defined its audience:

> "The report is intended to provide information primarily for public health policy-makers and managers, and for the wider medical and public health community (including pharmaceutical companies), as support for informing strategic actions and programme planning. It will also be of interest to the other sectors that are directly involved, including veterinary drug and animal husbandry, agriculture and aquaculture." (World Health Organization, 2014, p. XX).

One of the first audiences mentioned is the public health policymakers as they are the direct actors who have to express willingness to participate in the GLASS and pool the national resources, such as financial means, healthcare, and laboratory capabilities, among others, to standardise their AMR surveillance system according to the GLASS or build a new AMR surveillance system if it does not exist. Other groups, such as the medical and public health community are addressed as they are also seen as actors who can directly implement and standardise local AMR surveillance systems, for instance, by collecting AMR samples from the patients. Although GLASS does not broadly engage in One Health surveillance yet, the early GLASS document shows intentions towards One Health surveillance and addresses stakeholders in animal and plant health fields.

Another WHO document - *The GLASS manual for early implementation* - released in 2015 further defined a similar type of audience, although slightly narrower: "The intended readership of this publication is national public health professionals and national health authorities responsible for surveillance of antibacterial resistance in humans" (World Health Organization, 2015b, p. 2). This shows a shifted attention, particularly to the stakeholders in the human health field, and a focus on healthcare professionals and policymakers – stakeholder groups that are intended to directly implement the AMR surveillance system in their local context. However, one of the key groups in these documents from whom the samples for AMR data testing are collected – patients - is not directly addressed in the WHO documents as a readership group. Although later WHO documents have dropped these paragraphs on intended audiences overall, the similarity of the style of documents shows that the wider publics or collectives might not be primary audiences, despite AMR being shaped as a global threat

having negative impacts on all areas. However, the WHO documents on GLASS remain publicly accessible on the WHO´s website, although there are no indications of how or which publics engage with these documents.

Another top-down way how the WHO works with the local contexts as a global AMR surveillance coordinator is work with Collaborating Centres (CCs). A crucial part of enabling GLASS global AMR surveillance activities in local settings is through the Collaborating Centres (CCs). The resolution of WHA68.7 called for the establishment of the Global Action Plan on AMR and global AMR surveillance of GLASS as one of its objectives, and also "requested the WHO Secretariat to establish a network of WHO Collaborating Centres (CCs) to support surveillance of antimicrobial resistance and quality assessment in each WHO region" (World Health Organization, 2016b, p. 4). The collaborating centres are external institutions usually based on a country's national level and they collaborate with the WHO in various ways to facilitate the AMR surveillance capabilities by countries, territories, or regions.

For instance, collaborating centres often provide expertise to the GLASS on AMR surveillance, which is also influenced by the local capabilities that the CCs are aware of:

> "The general idea is that Collaborating Centres are centres of experts that can help WHO develop their programmes. So, for GLASS, we've actually been part of meetings where they wanted to discuss, okay, what pathogens should we include, what methodologies should we use (…) we basically provide advice, like for the next steps that they should take, how could they improve the quality of the data, should they add pathogens or not (…) they (GLASS) have expertise meetings, normally once a year" (Interviewee IV).

To this end, Collaborating Centres are institutions in the national countries that contain a particular set of expertise, for instance, epidemiological or estimating health burden caused by AMR, and are ready to voluntarily provide this expertise to the WHO for the implementation of the GLASS, particularly in a more local setting. However, as stated by the WHO documents, the Collaborating Centres' activities towards AMR surveillance should be coordinated together with the WHO, emphasising the role of the WHO as a coordinator. WHO foresees the collaborating centres prioritising their contributions to the WHO´s programmes and plans:

> "Activities should be jointly planned by the institution and WHO. WHO CC activities should be anchored in the WHO programme budget and directly contribute to WHO's programmes (as opposed to benefitting public health in general)" (World Health Organization, 2016b, p. 19).

The Coordinating Centres also provide their expertise voluntarily, while their funding sources might vary, as outlined by one of the interviewees, however, some centres do it for free for the exchange of expertise:

> "(…) so all the people in collaborating centres are basically providing voluntary participation (in the GLASS). In some countries the governments, the national governments provide some money for collaborating centres. In our (Collaborating Centre in the high-income country) case actually we're doing it for free, we don't get any national funding and it's just because we're interested and it's in our expertise level that we participate" (Interviewee IV).

However, as collaborating centres require a particular set of expertise and are not paid for their participation, there can be an inclination for CCs from high-income settings to be more active in helping and advising the WHO on AMR surveillance implementation and GLASS methodology.

As outlined above, GLASS as a global AMR surveillance system is reaffirmed by high-level political figures, the WHO´s expertise on AMR and other infectious disease surveillance, national countries, and international organisations, such as the United Nations. However, the WHO cannot implement these solutions and standards directly in the local contexts. Via GLASS, the WHO can only set up and coordinate the implementation of global AMR surveillance and its standardisation. Therefore, the implementation of AMR surveillance according to the global standards envisioned by the GLASS is delegated to the countries and their local settings, where the countries can show a different level of willingness to work according to the GLASS methodology in their local AMR surveillance efforts. In this way, the WHO not only assembles GLASS as a coordinator of global AMR solutions but also as a collaborator where the assemblage of GLASS occurs in a bottom-up way, depending on local willingness to collaborate with the WHO. The bottom-up assemblage of the GLASS emerges due to the previously existing AMR surveillance systems that are older than GLASS, and national countries´ willingness and capabilities to engage with (AMR) surveillance.

WHO´s efforts on AMR and AMR surveillance, such as GLASS, did not emerge in a vacuum. WHO´s endeavours were built on the other existing AMR surveillance systems as well as on WHO´s experience in surveillance in other disease areas. Before the establishment of the GLASS in 2015, other two bigger regional AMR surveillance networks existed. These surveillance networks are the Latin American Network for Antimicrobial Resistance Surveillance (ReLAVRA) and the European Antimicrobial Resistance Surveillance Network (EARS-Net) by the European Centre for Disease Prevention and Control (ECDC), both established in the 1990s. GLASS also often refers to the WHO's Central Asian and Eastern European Surveillance of Antimicrobial Resistance (CAESAR) which was also established in the same year as GLASS – in 2015. However, GLASS is the first AMR surveillance effort to be called "global" and reinforced by the WHO as well as by the participating countries' governments.

Next to the regional AMR surveillance countries, national countries present various efforts and willingness how to address AMR locally or globally without WHO coordination. For instance, in one of the documents, Sweden assumed responsibility to achieve freedom from the threat of AMR: "AMR

was a major cause of concern in Sweden. The collective responsibility was to ensure a world free from the fear of untreatable infections" (World Health Organization, 2017a, p. 14). Another example of national countries helping to tackle AMR on a global scale is the United Kingdom in supporting the building of laboratory infrastructures, including AMR surveillance. Fleming Fund from the United Kingdom invests in low to middle-income countries (LMICs) to strengthen the laboratory capacities required for surveillance. One of the interviewees described the Fleming Fund's work scope towards AMR surveillance:

> "(...) they are very clear, their remit is not research, it's purely strengthening surveillance, so, they find partners in country and they get then to work with laboratories in those countries to help them strengthen the capacity to do diagnostic microbiology and also ensure that as a part of that process, it is linked to generating good quality data in a format that can be easily shared with the national or coordinating centre of the AMR (...) and from there into the WHO" (Interviewee III).

Another interviewee emphasised the importance of the Fleming Fund, particularly its investments towards laboratory capacity building to enable better quality data that the WHO and the GLASS cannot achieve on their own:

> " (…) there is initiatives from a different setting, for example, something called Fleming Fund that are currently trying to improve, for example, lab-quality which is really going to help GLASS but it's not something that GLASS itself can do" (Interviewee IV).

Overall, Fleming Fund primarily invests in building laboratory infrastructures, providing materials as well as training required by the staff to work in the newly built laboratories. This work can be equated to better-quality laboratory testing and surveillance data as a result. The WHO emphasises such efforts as crucial because they fill in the gaps of expertise and resources that are unavailable to the GLASS and the WHO, particularly for building infrastructures in the local settings. The efforts of the Fleming Fund to strengthen AMR surveillance capacities are highlighted by the WHO documents as well (e.g. World Health Organization, 2016a, p. 8). WHO sees the potential of the Fleming Fund's activities towards enabling countries of sharing better-quality AMR data locally, regionally and globally, including GLASS. However, unlike collaborating centres, the WHO does not directly coordinate the work of the Fleming Fund and does not have a say, for example, where the Fleming Fund should invest, such as into what specific laboratories, technologies, and countries. Despite this situation, some interviewees envision that the WHO could take up the role of such funding coordination towards AMR globally:

> " (…) when I mentioned coordination, it was more of the support in countries cause there's many global actors or global partners working or initiatives working within countries in setting up, I don't know, lab strengthening for example, or implementation

> of national action plan (...) there's some global funds with funding but there's still different initiatives within the country for different reasons and you have a bilateral engagement and so on (...) So, this type of coordination (by the WHO) as well, I think is (...) needed to be strengthened" (Interviewee II).

However, there are no public accounts of how the WHO could coordinate national or regional funding towards AMR responses, including the implementation of local AMR surveillance systems. Funding towards AMR responses, such as global AMR surveillance systems, mainly depends on the willingness and priorities of the national countries and not so much on the WHO´s coordination of resources and other initiatives on AMR and surveillance capacities strengthening.

Overall, the WHO carved itself a role as a global AMR response coordinator, including the implementation of global AMR surveillance of GLASS. WHO justifies this role by its previous experience on AMR since the early 2000s as well as expertise in other global diseases, such as HIV, TB, malaria, and influenza, and their surveillance systems. This role is mainly reinforced by high-political figures and international organizations, as well as WHO´s member states who approved the Global Action Plan on AMR in 2015 during the World Health Assembly. However, the global health field proves to be much more complex and WHO cannot simply assemble GLASS in a top-down approach as a global AMR surveillance standardisation coordinator. Therefore, WHO also envisions itself as a collaborator, especially with other pre-existing AMR surveillance systems or initiatives on a regional level and national countries that show the commitment to tackle AMR on a global level themselves through their own investment decisions and global health agendas.

5.1.2.1. Voluntary principle in the global AMR data collection and standardisation

As outlined in the section above, WHO envisions itself as a coordinator and collaborator while assembling GLASS as a global AMR surveillance system. However, even in a top-down approach, where WHO is a coordinator of global AMR responses, it still needs to negotiate and rely on countries' capabilities in submitting AMR data to the GLASS in a standardized way. WHO requires expertise and financial resources from national countries to assemble a global AMR surveillance system as well as to build and strengthen infrastructures in local contexts. It also requires mundane everyday data collection, aggregation, and sharing efforts conducted in the countries where the AMR surveillance systems already exist. Multiple WHO documents as well as interviewed stakeholders emphasise a voluntary and flexible AMR data reporting principle. This means that countries are free (not) to report their AMR data according to their capabilities and own needs. The voluntary participation in the GLASS facilitated by the WHO is guided along the national and global legal frameworks or the lack thereof, while the voluntary participation system is perceived to have appropriate advantages and disadvantages as well.

First, AMR data reporting to the GLASS is defined by two documents: GLASS Guide to preparing aggregated antimicrobial resistance data files (World Health Organization, 2016c) and GLASS Guide

to uploading aggregated antimicrobial resistance data (World Health Organization, 2016d). AMR data is first collected by the medical staff in the surveillance sites, namely in the inpatient or outpatient hospitals. Then, this data is sent to the laboratories for testing and looking if the sample shows a resistant bacteria or not. This data is then aggregated on a country level from hospitals and laboratories by the national focal points that are usually represented by the countries' public health agency or ministry of health. The aggregated AMR data is submitted, checked and validated online via the GLASS IT platform to which national countries' representatives have access. Countries need to submit two files: the first file is on the resistance, namely, an aggregated "number of resistant, intermediate, susceptible (and other interpretations of AST results defined below) isolates detected in GLASS priority specimens, stratified by gender, infection origin, and age" (World Health Organization, 2016c, pp. 1-2). A second file is a number "of patients from whom specimens have been taken, stratified by the same variables as in the RIS file", such as gender, infection origin, and age (2016c, p. 2).

Via this process, GLASS enables multilevel surveillance, meaning that countries can submit the AMR data that the country collects for their purposes and not necessarily cover all GLASS-priority pathogens. Therefore, although GLASS asks countries to submit their AMR data, it also emphasises that AMR surveillance should be based on the country's own priorities, needs, and available resources. A minimal standard for the countries submitting their AMR data is to include "data on AMR combined with patient and microbiological information" (World Health Organization, 2015, p. 18), however, it does not specify from how many hospitals data should be collected or how many bacteria should be tested. To this end, GLASS AMR data collection and surveillance standardisation succumb to the national countries' contexts that present different (legal) requirements to which extent different bacteria are to be mandatorily or voluntarily reported. As one interviewee from a high-income country mentioned:

> "So, we do have a mandatory reporting of a few bacteria and antimicrobial combinations. And then we also have voluntary report system. So the voluntary report system, it's covering almost all the labs in (European high-income country), where it's basically everyday vacuums all the data from the regional labs (…) So, basically, these are voluntary but they only provide lab information, where mandatory will have all the patient information as well. And then we have some microbiological programs, but they are more for collecting some of mandatory and for national reference lab. So, let's say, the main one, it would go to the Ears-Net and GLASS" (Interviewee II).

In this example, the mandatory AMR data reporting within the national country is regulated by law and such data would then also go to the European surveillance system of EARS-Net or the GLASS. However, many other countries voluntarily decide whether to report to these systems or not as it is rare that such reporting would be defined by the law in the national context. AMR data reporting to the GLASS to some extent could be interpreted as required by the Global Action Plan on AMR that was

accepted by the WHO member states in 2015 via the World Health Assembly. Here, the WHO helps countries to "understand" their commitment toward AMR surveillance and AMR data reporting:

> "I think it's a part of the implementation to inform countries to understand their commitment. I mean they did, the member states of the WHO did accept the Global Action Plan, right? And it says to implement the national action plan, including surveillance" (Interviewee II).

However, unlike the national regulations, AMR reporting to the GLASS is not legally binding, despite the Global Action Plan on AMR and WHO member states agreeing on it. Therefore, this is solved by enabling different levels of participation, as one of the interviewees puts it:

> "WHO is very very dependent on political will of countries. They can't force anybody to do anything, so that's in a way really a shame (…) I think that changed a lot over time (…) there's more and more countries that are willing to do it. But then it's really dependent on funding, I think also within GLASS, they showed that there's more and more countries participating but (…) there's participating in different levels. So, there's countries saying, okay, we are willing and interested in looking at the AMR, so they've registered for GLASS but that doesn't mean that they already provide data or have any data. Some other countries are further, so they have some data but then they only record the lab data. Then, there's other countries who also actually provide more data about catchment, so you can look more at like the frequency of infections in a country. So, there's different levels of participating, participation" (Interviewee IV).

This different level of participation means that countries can participate in the GLASS without sending AMR data if the country does not have a functioning AMR surveillance system and a supporting infrastructure. However, the WHO expects that such a country that does not provide AMR data to GLASS is committed to building an AMR surveillance system and is willing to provide updates on its progress. On the other hand, if the country does have an AMR surveillance system, it can submit AMR data only on some of the priority pathogens according to its own needs. Although such visions of multilevel participation can enable more countries to participate in the GLASS, they also result in some of the data gaps following the GLASS priority pathogen list and AMR dataset that follows from such uneven data collection practices.

However, the WHO still perceives voluntary and flexible AMR data reporting as incentivising countries to participate in GLASS on their terms. Some of the interviewees viewed the voluntary participation in the GLASS and AMR data submission positively because voluntary participation can facilitate the complexity of AMR definitions and open up opportunities to test AMR with improved laboratory methods, while the mandatory AMR data sharing globally would be difficult to require legally on a global scale:

> "I would say for AMR (…) I guess the voluntary (reporting) would be the best way to go as the collection and sampling is based on the needs of the nation, I mean of your country, your priorities, what's important in your country. And also, I mean, the field is changing, you have a lot of molecular techniques now that will also change the definition of different species and so on (…) the legislation would be kind of rigid but there's pros and cons, I think" (Interviewee II).

On the other hand, voluntary AMR data reporting can create issues of motivation, especially because additional labour is needed to prepare and aggregate AMR data, particularly if the local system is different from the reporting requirements outlined by the GLASS. One of the interviewees thinks that it could be done easier if the national system corresponds to the GLASS. However, if the national system is different, a "translation" effort is needed which can be labour extensive and unmotivating:

> "GLASS is rather standardized with their data entry modules, so in that sense, all the data in the GLASS are collected in the same way but the question is how is the line from the central laboratory to the GLASS, how much does the national programme or national institute needs to do to prepare data to put into the GLASS. If that is completely different, then there is a lot of effort to translate your own laboratory data to a GLASS database. As soon as things cost a lot of effort, people don't do them. Especially because it is voluntary. You need a lot of motivation to have it done" (Interviewee I).

Overall, the WHO assigns a specific role for national countries and regions to implement the AMR surveillance system to fit into its global visions of standardisation. WHO needs countries to dedicate time and effort to collect, aggregate and share the local AMR data to the GLASS system. One of the incentives to participate in the GLASS is presented through a voluntary participation principle. Different levels of participation in the GLASS as well as voluntary and flexible AMR data reporting could be seen as a way to involve more countries to a global AMR surveillance. At the same time, mandatory AMR data reporting could be difficult to implement on a global level not only because of the missing legal frameworks but also due to the multiplicity of AMR definitions and improving laboratory methods that can change the understanding of AMR along the way. The current GLASS vision is that national AMR surveillance systems adapt their reporting to the GLASS requirements (top-down approach), however, under the GLASS voluntary AMR reporting system, data reporters can be unmotivated to submit their AMR data, especially if additional labour is needed to translate national AMR data and reporting to the GLASS system. However, such issues are not broadly discussed in publicly available WHO documents.

5.2. Knowledge practices in assembling global AMR surveillance and standardisation

5.2.1. Laboratories´ relevance in the global AMR data collection and standardisation: capabilities, visions, and competing standards

5.2.1.1. Capabilities and visions of laboratories for the global AMR data collection and standardisation

Laboratories are one of the key components for WHO to assemble the global AMR surveillance - GLASS. According to the GLASS methodology, the collected AMR samples in the hospitals are sent to the laboratories. In laboratories, data is analysed via antimicrobial susceptibility testing (AST). WHO also envisions other laboratory-based molecular methods for the future that would make AMR testing even faster and more precise. Although such methods are already conducted in many higher-income countries, they require a rather well-developed laboratory infrastructure and resources that are still not available in many countries or regions.

In laboratories, there are different methods of how samples can be tested and how AMR can be detected. Currently, the main GLASS method of laboratory testing for AMR is Antimicrobial Susceptibility Testing (AST). This means that in a sample, a pathogen (bacteria) is detected. These detected pathogens are then placed on the disc together with an antimicrobial substance and left for some time. After a specific waiting period, the disc shows a particular size zone on how pathogens did (not) expand on the disc. This zone is then categorised into three categories: susceptible (S), intermediate (I), resistant (R): susceptible (meaning that bacteria is not resistant); intermediate (bacteria shows some resistance but can still be treated with a higher dosage of the antimicrobial); and resistant (bacteria is resistant to antimicrobial it was tested against). This classification of when bacteria are resistant or not is based on the two global laboratory standardisation guidelines of the Clinical and Laboratory Standards Institute (CLSI) or the European Committee on Antimicrobial Susceptibility Testing (EUCAST). These systems determine the tested zone size and when the pathogen is resistant (World Health Organization, 2015b).

In addition to the AST testing, GLASS foresees that other molecular methods conducted in laboratories could be helpful for AMR surveillance. In 2019, GLASS published a document on molecular methods for AMR surveillance that could enhance the GLASS methodology (World Health Organization, 2019). This means that the laboratory technicians would extract the “resistance-coding genes or resistance-associated mutations in DNA” directly from the bacteria that is found in patient samples (2019a, p. 1). In comparison to AST, such molecular methods could provide faster results “in some cases in a matter of minutes if a cultured bacterial colony is tested directly or within a few hours for clinical specimens” (2019a, p.1). However, molecular methods are foreseen to complement AST and not replace it.

Another AMR surveillance method, where the laboratories are emphasised, is the method of whole genome sequencing (WGS). GLASS foresees that whole genome sequencing for AMR surveillance can improve AMR surveillance when combined with epidemiological and clinical information (World Health Organization, 2020b, p. v). Whole genome sequencing is particularly seen as a tool that could provide information on the early emergence and spread of AMR as WGS already showed promising results from drug-resistant tuberculosis and HIV. WGS method shows the DNA sequence of an organism and it "can be compared with a database of AMR genes and mutations in well-studied microbial genomes". This means that epidemiologists could track "the evolutionary history of newly characterized AMR organisms and disease outbreaks" which then could also help to formulate future predictions and response strategies (2020b, viii). However, both additional methods – molecular and WGS create additional complexities, such as more expensive laboratory devices, for example, fridges enabling lower temperatures, cartridges, additional reagents, batteries if there are electric power cuts, and additional training or expertise to interpret the results derived from molecular testing. Therefore, only AST results are so far required for the GLASS reporting, where countries can voluntarily decide if they want to send additional molecular AMR data to the GLASS.

All this AMR data is collected in the hospitals and then is envisioned to travel via the national networks to the GLASS. One of the interviewees from a high-income country explained this connection:

> "Our microbiology labs in hospitals are connected, however, it is voluntary. At the moment, I think, we have 80 per cent of the microbiology labs attached to this. So, they export their AMR data to selected samples, selected clinical syndromes, and selected microorganisms and they transfer them to the national database. From there, they standardise it and people can extract standardised reports (…) there is quite some work done to get this basic information from the majority of the laboratories. That is actually done in most of the western and northern European countries. These national databases are also linked and it is easy for them to be transported to the GLASS or EARS-Net, however, it does not mean that all data is complete. It is completely voluntary what is going to be transferred" (Interviewee I)

This means that the data from the laboratories travel back to the hospitals to confirm the diagnosis and that the laboratories are connected, particularly in higher-income countries, such as the ones in Europe. For the data submission outside of the country, such as AMR data to the GLASS or EARS-Net, depending on the country's capabilities, data can be collected from multiple laboratories as most of them are connected. This is particularly a case for Europe as laboratory systems for AMR surveillance are connected via EARS-Net which already started its activities in the 1990s. Countries can also agree to send their AMR data and relevant patient information to the GLASS if they are already participating and submitting data to the EARS-Net. However, in many countries and regions, such a connection is not the case and there is additional effort is needed to submit all this data to the GLASS.

One of the interviewees suggests that to motivate countries to report their AMR data to the GLASS, the reporting system has to be as seamless as possible, including the laboratory networks, however, it is not an easy task to link many different existing systems into one:

> "(…) how can we make sure that the effort that the national programme has to put in into the databases, such as GLASS or EARS-Net, is as effortless as possible. In my experience, merging or linking all these IT systems is causing more problems than it resolves" (Interviewee I).

Therefore, although seamless connection could be a potential solution, connecting all different data systems in practice, even in a national context, is a challenge that is way beyond the WHO´s and GLASS´ scope, capabilities, and expertise, while it also causes difficulties to the stakeholders on the national and more local levels. One of the solutions could be, as emphasised by another interviewee, GLASS being more adaptable regarding IT systems connection for AMR data reporting on the national or other local levels, instead of making other national or regional IT systems adapt according to GLASS reporting standards:

> "(…) it's a lot about the IT and you also need commitment from national level, really, to improve it (…) you shouldn't have to kind of change your own system adapted, rather GLASS should be more flexible" (Interviewee II).

Overall, the majority of GLASS AMR data and its interpretations, such as global or national AMR estimates, come from laboratory testing of potentially resistant bacteria, where samples come from hospitals collected from the patients. Therefore, to participate in GLASS fully and to submit their AMR data, countries, first of all, need functioning surveillance sites, such as hospitals and laboratory infrastructure as well as an overarching healthcare infrastructure. The laboratory infrastructure also needs to adhere to one of the global standards of the CLSI or EUCAST for the approved AMR testing by the WHO and for AMR data to be included in the GLASS. The list of GLASS participants confirms that the majority of countries submitting their AMR data to the GLASS are higher-income countries that have such infrastructures already established, connected and working. However, a higher degree of connectivity between different laboratories in countries or regions is also envisioned as needed for smoother AMR data reporting to the GLASS. Although issues of lacking laboratory capabilities are reflected in the GLASS documents, GLASS further envisions countries conducting laboratory-based AMR testing that require even more technological capabilities, resources, and expertise, despite many countries and regions still lacking the basic infrastructures. These molecular or whole genome sequencing methods are envisioned to complement current laboratory methods and make AMR surveillance faster as well as enable epidemiologists to predict AMR outbreaks better. Until and if such visions come true, GLASS collects AMR data yearly from the countries that are willing to submit it, mainly based on the AST results from the national laboratories.

5.2.1.2. Laboratories and the competing global standards

As presented in the sub-section above, most of the WHO´s visions for global AMR data surveillance require the capabilities and expertise related to laboratory-based AMR testing. To be able to participate in the GLASS, the WHO asks countries to conduct antimicrobial susceptibility testing (AST) in laboratories to determine whether bacteria are resistant or not to the available antimicrobials. To conduct such testing, countries need to have available laboratory infrastructures that adhere to international laboratory standards. Currently, two main global standard-setting organisations shape the laboratory standards on AMR testing: the Clinical and Laboratory Standards Institute (CLSI) which is based in the United States and was created in the 1960s; and the European Committee on Antimicrobial Susceptibility Testing (EUCAST) which is based in Sweden and was established in 1990s. CLSI is accredited by the American National Standards Institute, while EUCAST was created together by the European Society of Clinical Microbiology and Infectious Diseases (ESCMID), the European Centre for Disease Prevention and Control (ECDC) and some of the European laboratories. EUCAST´s main goal is to understand AMR and to create guidelines of how AMR can be understood, while CLSI focuses on broader standardisation tasks, such as laboratory equipment and information management, among others, while also focusing on AMR.

In the documents, WHO states that while testing AMR data to be submitted to the GLASS, countries need to adhere to one of the international standards: either to the CLSI or EUCAST to systematically determine whether the tested bacteria are resistant to antimicrobials or not. Interestingly, here we have two global standards that the WHO tries to use itself. However, as one of the interviewees stated, CLSI and EUCAST standardisation systems are not standardised among themselves:

> "(…) there are two global standards for AST reporting. So, you have EUCAST and you also have CLSI which is very widely used by some countries, so, it's kind of ridiculous that these are not harmonised. For one drug and for one bacteria, if labs follow one standard that report is sensitive and if they follow another standard, they report it as maybe resistant" (Interviewee III).

This difference comes to different measurements in "zones" while testing if the pathogen is resistant. Once the suspected bacteria and the antimicrobial are placed on the petri dish, there is a zone that expands or not. If the bacteria continue to grow on the petri dish, despite the antimicrobial being there, then the bacteria zone grows as well, meaning that the bacteria is resistant towards the tested antimicrobials. However, the EUCAST and CLSI have different standardisations on the width of these zones telling when the bacteria/pathogen is resistant and when not. As the interviewee further explains:

> "(…) the little disk on the agar plate and around where people measure how big the zone is. So, you actually need that in millimetres and the system that's being used in order to interpret it in a harmonised way, so, if you want to convert everything to

> EUCAST or everything to CLSI, you have to know how wide was that zone. If some report it as it was sensitive or it was resistant, you have no idea how big the zone was and whether under the other reporting system, it would also be susceptible or resistant. So, it makes it even harder and some of these standards change their zone sizes over the years for different pathogens, so what was sensitive five years ago is resistant today. Yeah, these kinds of other little, sort of systemic problems which all make standardising surveillance data even more difficult" (Interviewee III).

As mentioned by the interviewee, when reporting AMR data, the tested pathogens are explained as either resistant or not, however, countries are not required to provide GLASS with further details on the width of the testing zone. Therefore, the AMR definition can change over the years depending on which standard is followed: EUCAST or CLSI. Currently, GLASS is allowing its member countries to work with both standards for their laboratory quality assurance. However, there are some differences in participation conditions between these two standard systems. While CLSI membership requires fees, EUCAST methodology is free of charge. One interviewee argued that CLSI standards are more common, although countries need to pay to follow them:

> "For some reason, CLSI just took off more previously, I think, globally, because it was the USA initiative. But then you have people that can't afford it, so they are using out of dates standards as well" (Interviewee III).

This inclination toward CLSI could also be influenced by the CLSI existing almost 30 years longer than the EUCAST system as well as CLSI working on broader laboratory standardisation topics in comparison to EUCAST which solely focuses on AMR testing. However, WHO documents do not explore the in-depth differences between CLSI and EUCAST systems and how they may affect the understanding of AMR as well as the end dataset and reports produced by the GLASS. Although the European EUCAST system is preferred because it is free, WHO still supports countries, particularly those from lower-income regions that still use the CLSI system. However, the challenge with CLSI standardisation is that it requires fees because it is reviewed and updated yearly and countries that cannot pay for it might use outdated standards for AMR testing (World Health Organization, 2015c, pp. 1-2). Documents also show that WHO is slightly more promoting the EUCAST system for AMR testing based on sustainability argument: "WHO was not promoting EUCAST because it was cost-free but because its technical level was equal to CLSI so it was therefore good for sustainability" (2015c, p. 15). However, both standards for laboratory qualities are still accepted and expected by the WHO for its member states that submit data to the GLASS.

Overall, most capabilities that the WHO require for countries to participate in GLASS are related to the functioning of healthcare and laboratory infrastructures on the national level. Testing AMR in laboratories requires national countries' adherence to international laboratory standards that are not

necessarily harmonised among themselves. In this case, the WHO supports both global standards, although in the documents EUCAST might appear as a more enticing solution due to the low costs and visions that this standard is better for longer-term sustainability. As the countries only report whether bacteria are resistant, not resistant, or intermediate (showing that bacteria can still be affected by a bigger dose of antimicrobial) and do not record the width of testing zones, the WHO contains and facilitates different and changing understandings of AMR in its data. This limitation is only briefly reflected in the WHO documents, while more visible concerns relate to the CLSI costs and "outdated" standards if countries cannot pay CLSI for the newest standardisation guidelines. Despite these limitations, the WHO assembles the global AMR surveillance system of GLASS while being flexible and trying to facilitate both global standards of CLSI and EUCAST based on the member countries' selection.

5.2.2. Epidemiological relevance in global AMR data collection and standardisation

5.2.2.1. Epidemiological data collection via GLASS

Next to the laboratories' capabilities, epidemiological expertise is probably one of the key sources assembling GLASS as a global AMR surveillance system. According to the GLASS methodology, laboratory AMR data should be supported by epidemiological data as well. Here, surveys and studies come as one of the key methods to supplement AMR routinely collected data with additional patient and hospital information.

Epidemiological data is collected through the third horizontal level of the GLASS called surveys and studies. It includes four data modules: "Enhanced Gonorrhoeae Surveillance" (EGASP), "Integrated multi-sectoral surveillance" (ONE HEALTH), "Point prevalence survey on antibiotic use in hospitals" (PPS-AMU), and "Studies for estimating antimicrobial resistance burden" (BURDEN) (World Health Organization, 2022a). Overall, different surveys and studies present different capabilities to support the laboratory-based AMR surveillance and data gaps that are perceived by epidemiologists. Surveys and studies help to collect additional epidemiological patient information that could help to better understand AMR and that is not automatically collected via the clinical practices while healthcare staff is treating patients, collecting samples, and aggregating patient data.

One of the most prominent examples in the WHO documents is the BURDEN module concerning the AMR health burden calculations. Before the establishment of the GLASS, the WHO conducted a systematic literature review and concluded that there is a lack of data on AMR health burden estimations as well as a lack of standardised methodology of how to calculate these estimates on a global level (World Health Organization, 2014). Therefore, the WHO carved out the gap for the need for global AMR health burden estimations already with the Global Report on Surveillance published in 2014,

before the establishment of the GLASS. To this end, GLASS aims to conduct AMR health burden estimations through its "Studies for estimating antimicrobial resistance burden" or BURDEN module. Although this data collection module is primarily based on surveys and studies, laboratory-based infrastructure is still needed because there is a need to determine first whether the patient has a resistant infection at all. If such cases are confirmed, additional information can be collected to estimate AMR health burden.

The need for AMR health burden estimations was reinforced by the GLASS meeting with WHO experts consulting on AMR health burden estimations (World Health Organization, 2018b). During this meeting, the rationale for estimating AMR health burden was reviewed. For instance, one of the AMR health burden estimation studies in Thailand showed that:

> "The patients with antibiotic-resistant bacteraemia consumed more resources than those with antibiotic-non-resistant bacteraem. Blood culture results combined with patient clinical data were shown to have more benefit for surveillance of antimicrobial resistance, and to be more applicable for developing local antibiotic treatment guidelines for patients suspected of having bacteraemia" (World Health Organization, 2018b, p. 5).

Therefore, WHO presents that additional patient data collected next to the laboratory values have the potential to support laboratory-based surveillance of resistant pathogens as well as to provide benefits to the patients and doctors making treatment decisions and assigning antibiotics that in the end could limit AMR.

Other discussions during the WHO expert meeting revolved around agreeing on how the AMR health burden should be estimated. The WHO experts decided to follow the WHO's Global Burden of Disease methodology and choose the disability-adjusted life-year (DALY) "as a single measure to quantify the health impact of AMR and associated risk factors" (World Health Organization, 2018b, p. 8). Potential conditions that could contribute to DALYs caused by the AMR were outlined to be "dialysis, amputation, paralysis, and sepsis (...) that could heavily impact DALYs based on their related disability weights" (2018b, p. 9). However, during the meeting, experts also recognised that the AMR health burden estimations are not that straightforward and some mathematical and statistical modelling will be needed to determine what data could reflect the AMR health burden the most:

> "The initial aim is to collect data on a wide range of factors, and use mathematical and statistical methods to define which variables have a large effect on possible outcomes and should be included in future surveillance" (2018b, p. 9).

The meeting between WHO experts in 2018 again emphasised the need for AMR health burden estimations and their global standardisation as well as discussed potential solutions for how such estimations could be calculated. As such calculations are complex and especially on a global scale, the

WHO agreed to pilot and calculate AMR burden based on a straightforward mortality measurement, while leaving the more complex mathematical and statistical calculations for the future.

In 2020, the WHO published a methodological document on the GLASS method for estimating attributable mortality of antimicrobial-resistant bloodstream infections (World Health Organization, 2020c). Although previous discussions in 2018 talked about AMR health burden estimations and their standardisation by using DALYs, GLASS simplified its first approach towards AMR health burden estimations and started with pathogens in bloodstream infections by solely estimating mortality caused by AMR. Via GLASS, the WHO currently focuses on two bacteria that can show resistance to antibiotics and be found in the blood: *E. coli* which can cause stomach cramps, diarrhoea, vomiting, and fever, and *Staphylococcus aureus* which can cause skin infections, pneumonia, meningitis, or sepsis. One of the interviewees explained how GLASS conducts AMR health burden estimations:

> "(…) it's much more about, yeah, having hospitals in practice, they actually track what happens to people who come in, get antibiotics, then they see what they get diagnosed with, so a proportion of them will get diagnosed with a pathogen in their blood, a proportion of those will be GLASS priority pathogens, and then you find whether the patient lived or died, how long were they in hospital, and then 28 days after the infection, are they alive or dead (…) it does collect a lot more useful data when you try to define the burden of AMR and the impact on people. So yeah, it's like this enhanced sort of surveillance" (Interviewee III).

Therefore, with its BURDEN module, GLASS collects additional data about patients next to the laboratory results on AMR samples. Once the patient has been tested for a resistant pathogen in their blood, GLASS methodology advises following the patient for an additional 28 days and see what the patient's outcome is, namely whether the patient has survived or not. Other data include the length of the hospital stay and other similar variables that are also collected by other GLASS modules. However, the main data point is whether the patient survived the infection or not after being admitted to the hospital. The GLASS BURDEN module is still in its early stage and the simplest measures are selected, such as mortality, with more straightforward bloodstream infections and bacteria to observe in the blood.

GLASS selected bloodstream infections for this module because of the straightforward definition and the high mortality rate that these infections cause. One of the interviewees explained the rationale for this GLASS selection of how to initially start calculating AMR health burden:

> "The first thing is definitions. Because you can do a culture in a lab and find a bacteria but that doesn't necessarily mean that that patient has an infection. For example, if you have, for urinary tract infections (…) they test whether in your urine they can find bacteria but if they are not above a certain threshold or if they are not of a certain type,

> it could mean nothing, really, even though you find a pathogen. And the easy thing for bloodstream infections is, you shouldn't have any bacteria in your blood. So, if you find a bacteria, you're sure that that patient is infected. So, in that sense (…) the definition is very straightforward and that makes very easy to compare different settings because you know all of these patients that they have a positive blood culture, they're all infected" (Interviewee IV).

Therefore, the straightforward method of conducting surveillance for bloodstream infections is seen by the WHO as more affordable to countries as it does not require advanced laboratory and healthcare expertise to determine the pathogen´s resistance in the blood. However, such a rationale can also ignore the conditions in local settings that do not possess sufficient healthcare and laboratory infrastructures for such testing at all. Another rationale for selecting bloodstream infections for determining AMR mortality emphasises the estimated high mortality rates caused by pathogens in the blood:

> "(…) bloodstream infections are the most serious infections that the patient can get, and, for example, the mortality is quite high and that's one of the outcomes that we often look at for burden. So that makes more sense because, for example, for urinary tract infections, there's not going to be a lot of mortality, there's all kinds of other things that are important as well and can have a big burden for patients but it's not going to be mortality. And mortality again is very easy to measure, it's a very objective endpoint" (Interviewee IV)

This shows that bloodstream infections were selected not only because of methodological simplicity but also to observe and show a high AMR burden through high mortality rates of humans who experience a resistant infection in their bloodstream. It is easier to measure mortality in bloodstream infections in comparison to other diseases or their cumulative effects on human health, where it is difficult to determine whether AMR was the sole cause of a patient´s death or not. In addition, as the interviewee emphasised, mortality is also more straightforward to measure, unlike other possible AMR health burden estimations via DALYs. At the same time, testing bloodstream infections still require at least some laboratory infrastructures that are not always available to all countries and regions. As one of the interviewees noted:

> "But if you start talking about bloodstream infections where you need to incubate the specimen as quickly as possible at 3 to 8 degrees or something like that, yes, that becomes really really problematic" (Interviewee I).

This means that more mundane infrastructure for collecting samples of human blood and preparing it for testing, such as tubes, fridges that can maintain low temperatures, and sufficient power supply to allow the electrical devices to run, are still needed and not always available in different regions. This is still needed next to the additional information and data labour required to follow up with the patient

after 28 days of hospital admission as well as collect additional patient data and submit it to the GLASS BURDEN.

Currently, the GLASS BURDEN module is still in its inception phase, however, its implementation progress remains vague in the publicly available sources. BURDEN module and AMR health estimations by the GLASS were foreseen to be practically implemented by the WHO "in the second quarter of 2021 in selected countries in Africa and South-East Asia through the "A Clinically-Oriented Antimicrobial Resistance Surveillance Network (ACORN)"" (World Health Organization, 2021a, p. 52). The WHO documents also emphasise that: "Other external partners, WHO Regional Offices, and GLASS-enrolled countries, have expressed an interest in aligning with and applying the protocol in the coming years" (2021a, p. 52). However, no further updates are provided by the WHO's openly accessible documents that could show to what extent the GLASS methodology on AMR burden was implemented or which countries participate, and what were the potential results of such study. This could relate to the COVID-19 pandemic as the GLASS has already referred to the negative effects and delays to the AMR surveillance caused by the COVID-19 pandemic in its yearly report for 2021.

Overall, GLASS currently conducts surveys on AMR-attributable mortality with the vision to expand AMR health burden estimations and standardise them globally. Via its documents, WHO carved out the need for AMR health burden estimations as they are inconsistent globally and such estimations could also potentially fill in the gaps for laboratory-based pathogen surveillance. To this end, GLASS started with a smaller scope of AMR health burden estimations, and they are conducted mostly in lower-income regions. As health burden estimations are already being conducted by other countries, mostly from higher income regions, or other organisations, such as European Centre for Disease Prevention and Control (ECDC), with its efforts, the WHO fills in the gap as a coordinator of lower-income countries in prioritising AMR and potentially aiming to standardise such estimations globally. However, such efforts are still ongoing, while publicly available documents do not provide updates on how these studies are moving forward.

Another module where additional epidemiological data is collected is called the "Enhanced Gonorrhoeae Surveillance" or EGASP. This module is built on the previous WHO surveillance efforts in the *N. gonorrhoeae* pathogen monitoring on a global scale that started in the 1990s. EGASP has been launched in 2018 as part of the GLASS and currently involves three countries: Thailand, Cambodia, and the Philippines. Although the GLASS-AMR module collects information about *N. gonorrhoeae* pathogen from the countries yearly, EGASP is seen as an "enhanced" module that collects additional epidemiological data from the patients. The list of this additional data is outlined in the WHO´s document "Enhanced Gonococcal Antimicrobial Surveillance Programme (EGASP): general protocol" released in 2021 (World Health Organization, 2021b). According to the protocol, additional patient data collected encompasses similar variables as outlined in the GLASS-AMR module, such as the patient´s age, gender, disease symptoms, and other variables relevant to the patient history. Additional data

collected as a part of the EGASP module involve the history of travelling and sexual behaviour patterns, as well as data on patients and their partners´ ethnicity (2021b, pp. 26-33).

EGASP is also presented as a module that combines the collaboration between the WHO (not only GLASS but also the WHO collaborating centres on sexually transmitted diseases and the United States Centers for Disease Control and Prevention, or CDC). Currently, there is no longer list of countries available in the publicly available WHO documents that would show who participates and submits their data to the EGASP, except for initial participants of Thailand, Cambodia, and the Philippines. At the same time, the data submitted to the EGASP can be accessed not only by the WHO but also by some of the appointed officials from the United States Centers for Disease Control and Prevention, Division of STD Prevention, National Center for HIV/AIDS, Viral Hepatitis, STDs and TB Prevention (CDC/DSTDP/NCHHSTP) from the United States. The rationale for these institutions to access this data is to "provide support with data collection and data quality", however, this type of access first needs to be agreed upon with the national health ministries of countries that submit their data (World Health Organization, 2021b, p. 12). Therefore, it appears that countries participating in this module have agreed for the data to be accessed and analysed by CDC and similar bodies in the United States.

Overall, studies and surveys modules of the GLASS provide additional epidemiological information and data supplementing the laboratory-based surveillance, whether it would be on AMR health burden, a particular pathogen, such as *N. gonorrhoeae,* or aiming to expand the One Health surveillance that was already emphasised in the Global Action Plan on AMR in 2015. All these modules draw from the expertise of the WHO or other organizations, for instance, the CDC in the United States, the WHO's Global Burden of Disease methodology and experience on DALYs; or the WHO Global Gonococcal Antimicrobial Surveillance Program (EGASP) running since 1992. This expertise of the WHO then directly feeds into the current GLASS data modules of surveys and studies. These modules are eventually envisioned to provide additional epidemiological information about the AMR data collected mainly via the GLASS-AMR module and to support the data obtained from the laboratory-based surveillance or even to collect at least some data if the laboratory infrastructures are limited in some countries or regions.

5.2.2.2. The epidemiological issue of representativeness

Epidemiological expertise is one of the key sources of knowledge informing the GLASS AMR surveillance endeavours and assembling GLASS as a global AMR surveillance system. However, this type of expertise creates specific issues that would not be that visible to other experts or stakeholders, for instance, clinicians or policymakers. One of the main (epidemiological) issues that emerged during the document analysis and interviews was the lack of representativeness of AMR data which asks whether AMR data collected by the GLASS truly represent AMR rates and AMR issues globally.

As outlined in the sections above, WHO emphasises the collection of AMR data via the laboratory infrastructures for the majority of the GLASS data modules. At the same time, the AMR data coming from laboratories is also envisioned to be combined with the epidemiological data. This combination would allow the WHO to estimate "whether most AMR infections are occurring, e.g., in young or elderly people, in the community or in hospital, and the geographical distribution of infections caused by resistant organisms" (World Health Organization, 2015b, p. 18). One of the interviewees with epidemiological experience observes that the GLASS-selected methodology for AMR surveillance is complex and expensive, especially because simple epidemiological data from surveys are not enough and testing from laboratories is needed:

> "So to actually get a meaningful dataset takes time, so, I think, it's just a much more challenging problem than other global programmes like malaria, HIV, TB, where (…) you can kind of get information you need in a simpler way in a survey type of approach. This (AMR surveillance) is much more complex and, yeah, demanding of resource, time, and also much higher degree of laboratory expertise (…) I just think it's much harder to do" (Interviewee III).

Obtaining AMR data requires an extensive amount of time and resources and although the WHO and GLASS emphasise that they can draw experience and lessons learned from other diseases´ surveillance, such as malaria, HIV, or tuberculosis, the phenomenon of AMR itself can be more difficult to collect data on because laboratories and healthcare infrastructures for AMR data collection are presented as crucial. At the same time, AMR surveillance based solely on laboratory testing can be problematic as presented by the WHO and epidemiologists because, without the additional data, epidemiologists cannot see if the tested population was representative to show AMR rates on national, regional, and global levels.

The WHO´s documents and interviews conducted for this thesis draw attention towards an issue of representativeness due to the hospitals´ capabilities to test patients versus the inability to test the entire population. The representativeness issue in AMR data emerges as hospitals do not sample the entire population – only the persons who show some symptoms relevant to infection that may be resistant to currently existing antibiotics. However, hospitals cannot test all the patients in the population who have an infection, particularly patients that do not come or do not have the means to come to the hospital. This was emphasised by one of the interviewees:

> "For infections that do not always result in the hospitalisations and also not often resulting into a diagnostic clinical work – then, laboratory surveillance is much more problematic" (Interviewee I).

As emphasised by the WHO documents and interviewees, this leads to a potential bias created in the AMR data collection which may affect the understanding of national and global AMR rates and that

they are reported to be higher/lower than they are, or some population might be misrepresented (e.g. that one age group is more prone to resistant infections than the other age group). For epidemiologists, the issue comes from the lack of additional or epidemiological data, namely, how the AMR data was collected in the local sites and any metadata surrounding the AMR surveillance. At the moment, countries report "aggregated" AMR data to the WHO while following the GLASS requirements:

> "(…) at the moment, GLASS still only collects aggregated data, so not patient-level data which also means that it's kind of difficult to do quality checks and to understand what they (countries) are really reporting" (Interviewee IV).

The aggregated data means that countries send data about how many pathogens isolates they tested and how many of them were resistant. However, countries do not provide information on how many overall patient samples from the hospital were collected and it is unclear how many of them were tested for AMR and why those samples were tested or not. As another interviewee described it, although samples are tested, other information about them is missing, such as why the sample was collected or what were the medical signs and symptoms that can be associated with the disease:

> "You have the information present in the laboratory in the freezer but there is no clinical syndrome, you don't know why these specimens are collected in the first place (…) If you really want to know what is going on so then you would need to do some active surveillance with surveys to get a grip of it. Now, of course, also (Asian national country) has some kind of national collection of AMR data in the national institutes but they can only work with what they get and they don't know how representative that is. So, it is very difficult to make any insights on these data in those government institutes that compile them" (Interviewee I)

Therefore, although AMR data can be collected, it is unclear what conclusions or knowledge can be created out of this data due to the lack of representativeness or additional data needed by epidemiologists, for instance, by actively conducting surveys in hospitals or other surveillance sites.

At the same time, the issue of unrepresentative data is particularly relevant to epidemiologists. While medical staff collects data for diagnostic purposes, including data for AMR, for epidemiologists such data collection is insufficient as it is not representative and makes it difficult to conduct their knowledge practices:

> "And I think that it is also a problem that AMR surveillance has at the moment, even the AMR surveillance by the GLASS system. That is all voluntary based, all coming from laboratories, but there is no specific representative sampling. So, for me, as an epidemiologist, it is very difficult to interpret those data because I don't know where they come from, what is the interpretation of a certain percentage or a certain prevalence" (Interviewee I).

Therefore, the knowledge created by the epidemiologists is based on the need for more data – including studies and surveys – and not only on the AMR data coming from laboratory testing without additional information. The epidemiological data combined with laboratory data could help epidemiologists to conclude, based on prevalence, a share of a specific population that is affected by AMR at the time of testing. At the same time, epidemiological data is needed not only to create knowledge but also to double-check the data and to ensure that epidemiological interpretations are based on high-quality and correct data. One of the interviewees emphasised that unrepresentative data collection creates a data quality issue as well:

> "if you have aggregated data, you can no longer check those things. And, also, like, it gives countries the option to just report an estimate instead of the true data and you can't really check that" (Interviewee IV).

Interviewees further shared visions of how the representativeness issue could be solved. One interviewee suggested that although a lot of work and procedures are needed to ensure a representative dataset showing AMR rates, automation of laboratory processes could help address the representativeness issue, although it is an expensive solution:

> "If you are trained microbiologist, you can quite quickly see that there's lots of really bad data out there because the lab needs lots of quality management and quality assurance and they involve so many steps and regiments. It's just (…) really hard work to do and it's really hard to know that the data that's being produced by lots of labs is good enough quality and I think it isn't, so, I think a big thing (…) does need to be tackled, how I am not sure. Maybe through more automation but that will cost more money" (Interviewee III).

Automation with less human labour is also envisioned in the WHO documents. In the face of the challenges relevant to surveillance, including global AMR surveillance, automation and real-time AMR data analysis are one of the envisioned solutions for future AMR surveillance:

> "The GLASS data call timeframe has proven to be a challenge for several countries, including those with existing functional AMR surveillance systems. However, the effort put into GLASS IT development this year is targeted at the creation of a fully automated system that will allow in the future for an almost continuous flow of information gathering and real-time analysis of the data. This will be particularly important to monitor AMR trends and will allow better synergy with existing surveillance systems" (World Health Organization, 2018a, p. 243).

The potential use of artificial intelligence (AI) is mentioned in the WHO documents as one of the solutions for global AMR surveillance (World Health Organization, 2018d, p. 11; World Health Organization, 2019, p. 20). The use of AI is envisioned to be able to analyse AMR data as well as

predict AMR future trends based on the AMR data collected in real time. However, the implementation of such complex technological solutions of real-time AMR data collections and AI predictions do not have a concrete timeline and does serve as a longer-term vision. This is particularly understandable as some countries and regions still do not have the basic infrastructures required for antimicrobial susceptibility testing and timely reporting of the results to the GLASS. However, despite some of the countries and regions missing the basic elements for the envisioned global AMR surveillance, the WHO and experts in the field continue imagining even more complex technological solutions that are seen as having the potential to close these gaps.

Overall, epidemiological expertise plays a key role in the understanding of AMR surveillance and assembling the global AMR surveillance system of GLASS. However, epidemiological expertise tends to see particular limitations related to global AMR surveillance, such as the data representativeness issue which is carved out as one of the key challenges in GLASS activities. The representativeness issue stems from the need for epidemiological data, meaning that epidemiologists need additional AMR metadata next to the laboratory testing results as data coming solely from laboratory testing from hospitals is insufficient for epidemiologists to understand AMR data and, for instance, count the prevalence of AMR in the population. Partly, epidemiologists and the WHO envision this issue to be solved by improving technological capabilities, such as the collection of real-time data, big data, and AI. The epidemiological expertise and requirements for epidemiological data collection can translate differently in local contexts, where the data is collected, aggregated, and shared. Stakeholders on a local level, such as clinicians could see AMR data collection differently and emphasise different issues than epidemiologists, as shown in the sub-section 5.2.3

5.2.2.3. Envisioned outcomes of the global AMR data collection and standardisation

Although the WHO has strong visions and rationale of how and why global AMR data should be collected via GLASS, visions of what is the outcome of AMR data remain vague. Therefore questions on when the AMR data collected by the GLASS is representative and global enough to create knowledge and how much data should be collected to create sufficient and representative knowledge to address AMR remain under discussion.

As told by one of the interviewees, a potential way how to deal with all global AMR data is to enable research efforts that could be based on AMR data collected by the GLASS. One interviewee envisions that particular interventions against AMR could be developed based on the AMR data collected and the following research efforts:

> "I think, it will take research to understand which interventions are going to work because you can't just copy what's going on necessarily elsewhere and there might be better ways with big data, artificial intelligence, who knows what the solutions might be to kind of stop irrational prescribing (…) or is it to do with our patient are crowded

> together in the ward or is it to do with understaffing, or who knows what the magic answer could be. I don't think we know yet what would be the most effective interventions but this data collection has to be for something" (Interviewee III).

The interviewee also emphasised the solutions created for particular local contexts, instead of one size fits all interventions, where technical solutions such as big data or AI could be helpful. Data could potentially help to create knowledge not only on possible interventions for AMR but also to understand why AMR emerge in the first place. The interviewee shares a common understanding of AMR being caused by antibiotics use and misuse. The interviewee could not imagine the potential interventions that could stem from GLASS data, however, the presented examples go along the line of antibiotics prescriptions and reducing the use of antimicrobials:

> "(…) this data is supposed to inform interventions, I don't think we know really yet what those interventions would be and until we know how these pathogens are really harming patients, that's going to be really difficult, so, you can keep describing year on year that it's getting worse but it doesn't help you know what to do about it or which part to tackle first" (Interviewee III).

Other visions of AMR data use include the development of other medical interventions and technologies, outside antibiotics that could help to counter AMR. Such examples include vaccines and mononuclear antibodies that could help to tackle infections without or with fewer antibiotics:

> "One of the newer prevention strategies that currently is being invested in are vaccines and mononuclear antibodies. And for that, we actually need to know what pathogens are the most relevant to start to develop something like that because that's a very expensive and long process. So, it would be important to know what pathogens should we focus on, and also, if we have something, in what population should we try and start to implement it to have the most effect" (Interviewee IV).

However, as developing new medical interventions can be a long and expensive process, AMR data collection could help with pathogen prioritisation, namely, to determine which bacteria cause the most harm and needs to be prioritised for the creation of a particular medical product. However, GLASS already has its seven priority pathogens selected for AMR surveillance, while countries do not necessarily need to report their AMR data on all pathogens, meaning that this prioritisation of bacteria for medical product intervention could also be biased. In addition, the visions of surveillance outcomes often refer to the technological and medical solutions to counter AMR – vaccines and mononuclear antibodies. Such interventions might still take years to develop, and they could be developed mostly by the countries, regions, or companies that have dedicated resources for this.

Overall, it is not entirely clear what all this AMR data, even when representative, should result in or when sufficient data is collected to create knowledge on AMR. While GLASS presents AMR data

generally as a basis for knowledge and policy interventions towards tackling the AMR threat, it is unclear who should produce this knowledge (although there are hints that AI could predict AMR future trends) or what potential interventions could result from this data. Some of the envisioned potential interventions go along the lines of reducing antibiotic use and creating new medical products, for example, vaccines, that could potentially reduce AMR rates. However, decisions need to be made on what pathogens should be prioritised in AMR data collection as it is expensive and time-consuming to create a new medical intervention to tackle AMR.

5.2.3. Clinical expertise and relevance in the global AMR data collection and standardisation

Clinical expertise is one of the key sources in assembling GLASS as a global AMR surveillance system as it directly collects AMR samples and sends them to the laboratories. It is particularly relevant in routine AMR surveillance via the Antimicrobial Resistance surveillance (GLASS-AMR) module.

As outlined in the GLASS Manual for Early Implementation released in 2015, AMR data is first collected by the medical staff in the surveillance sites on the national level which usually are inpatient and outpatient medical centres. The GLASS envisions routinely collected AMR data coming from the four prioritised human samples: blood, urine, faeces, and urethral and cervical swabs. These sample types were selected by the WHO because "they represent infections in the bloodstream, urinary tract, gastrointestinal tract and gonorrhoea" (World Health Organization, 2015b, p. 9). GLASS documents state that these infections and related pathogens show a steady global increase in resistance "to drugs of last resort", namely the antibiotics that still show effectiveness against these infections. In addition, the selection of these sample types is justified as they can be tested with "uncomplicated laboratory methods" (2015b, p. 9), although many countries and regions still do not have infrastructures to support even the envisioned "simple" methods.

The data on AMR, including samples and variables, are primarily collected by clinicians. If a resistant infection is suspected in a patient, a clinician sends a sample to a laboratory which can be either local or, if unavailable, it might be a national-level laboratory also called a national reference laboratory by the WHO (World Health Organization, 2015b, p. 13). However, collecting samples in hospitals and sending them to the laboratory is not only a practice for conducting AMR surveillance. As one of the interviewees emphasised, such practice is required for the diagnostics of the patient:

> "The Laboratory-based surveillance can be very good if you want to know what is going on in your intensive care unit, just look at the AMR in your hospital because everyone in the ICU will have their specimens submitted. That would be a very good laboratory surveillance" (Interviewee I).

Therefore, outside of the GLASS methodology, AMR is already being tested in patients, for example, in the intensive care units (ICU) if medical staff suspects that the patient suffers from a resistant infection or if the assigned antibiotic treatment does not work.

Although patient data testing in laboratories is a common procedure in many hospitals in different local contexts, based on the WHO´s manual (World Health Organization, 2015b, p. 6), together with the data from the sample testing, the following AMR data variables need to also be submitted to the GLASS by the participating countries:

- Size of the country's population
- The number of patients in the last year and whether they were consulted in an outpatient or inpatient facility
- "The numbers of patients with positive and negative cultures per specimen type and with susceptible and non-susceptible pathogens for each priority pathogen–antibiotic combination per specimen type, stratified according to core patient data" (2015b, p. 6)
- Patient age
- Patient gender
- Data on patient admission, i.e. whether the patient was admitted in an in-patient clinic or consulted in an out-patient clinic; when the samples were taken; and whether the patient was transferred between hospitals.

To collect AMR data that is standardized and representative on the global scale, data collection labour is needed from the local contexts. However, in some environments, such as hospitals, data collection can create additional strain in an already busy work field and not fully correspond to the actual local capabilities for AMR surveillance and its building or standardisation on a global scale.

As the WHO documents emphasise, all AMR data submitted to the GLASS first needs to be collected and aggregated on the national level. Therefore, data aggregated at the national level first needs to be collected in surveillance sites – mainly hospitals (inpatient or outpatient) or other similar healthcare centres. In some local contexts, AMR data collection and especially additional epidemiological information that is supposed to come with it create additional labour for the doctors and other hospital staff involved who are already working in understaffed, underpaid, and strained environments. As one interviewee told:

> "If we think that most government hospitals in low to middle-income countries are understaffed and staff are often not very highly paid (…) in a lot of countries in Asia doctors, for example, lab scientists need to find another job in the evening in order to have enough income (…) So, it's quite hard when you have people who are already extremely busy to say to them, oh yeah, while you're at it, please can you just fill in ten forms on all your patients to say when they arrived, what drugs did they get, what

was wrong with them, did they survive. It just takes (…) people's time, money, and then, of course, you would come down to the design issues around selecting representative populations because we never know if we are comparing like with like when we look at all these surveillance datasets" (Interviewee III).

Therefore, doctors would not only need to collect additional epidemiological information to send to the WHO but also to help to ensure that the collected data show a representative population as required by the epidemiologists. Also, collecting additional patient data on AMR requires additional resources and it is not clear how to obtain them or who should provide them as well as whether this additional labour dedicated to the AMR data collection is purposeful and whether it will result in a representative dataset that will be used and trusted by the epidemiologists or other stakeholders who are envisioned to conclude data on global or national AMR situation and come up with knowledge and solutions.

Additional data collection is required not only for the routine surveillance of GLASS-AMR but also for the global AMR health burden estimations and their standardisation that also expect additional local capabilities and labour. One such additional capability includes the documentation of the cause of death and additional labour needed to collect data points from the patients to calculate the AMR burden of mortality. To this end, it can often be difficult to assess what was the exact patient's cause of death, especially if there were other parallel diseases or conditions, and whether only AMR could be named as a person's sole cause of death:

> "The problem with drug-resistant infections is that you can die with your infection and not because of your infection. So, if you are just recording whether patient died or not, that's not going to give you that much information because it is not necessarily related to the drug-resistant infection. Most patients that get drug-resistant infections are already very sick, so they might die because of all those other underlying diseases and not because of the infection" (Interviewee IV).

To counter this methodological surveillance issue, additional data labour is needed, particularly by the medical staff to collect additional data about the patient´s other underlying diseases and treatment. Such data labour would include setting up separate AMR mortality estimation studies in the hospitals and collecting data about underlying patient conditions next to AMR data. As one of the interviewees puts it:

> "(…) we need to do specific studies but that means (…) centres need to set up studies, they need to have research nurse actively collecting extra data about like the underlying disease of the patients, they need to match controls to the patients with drug-resistant infections, so it's very time-consuming and it needs some resources as well. So, this is not something that you can be doing on a regular basis. This would really be sort of

> like one study that you do, I don't know, every other year, and then, also, like how many centres do you need to include to make it representative" (Interviewee IV).

However, as mentioned by this interviewee, such additional studies can be expensive and burdensome for hospitals, meaning that not many hospitals could afford them in the first place. This again comes to the epidemiological concern of representativeness and bias because only hospitals and patients that can afford to participate in the study with additional data collection on AMR health burden would be included. In addition, surveillance systems methodologies, including GLASS, are also designed in a way where surveillance sites are usually hospitals and the tested population consists mostly of patients.

As outlined in the sections above, the WHO documents often show stakeholders who are envisioned to be involved in the creation of the global AMR surveillance, such as policymakers, public health representatives and epidemiologists, clinicians, and at some times, representatives for animal and environmental health. However, the key provider of AMR data – patients – are not directly addressed by the publicly available WHO documents on global AMR surveillance and WHO´s visions. This could be an issue as in some local contexts obtaining AMR data from the patients create direct costs to them and can also influence how much AMR data can be collected and from whom. In some local contexts, the laboratory testing required for AMR is not supported by national health insurance or provided by the healthcare system. This can be a case in many lower-income countries (although not necessarily as, for example, the United States does not provide universal health insurance as well), where patients need to pay out of their own pocket for laboratory testing for their samples if doctors suspect that their infection is resistant to antibiotics. This story was told by one of the interviewees:

> "(…) we did a health economics analysis which shows that (…) the average costs about blood culture to test is about 22 dollars and (…) when you look at the GDP of most low to middle-income countries, this is just not going to work. People can't afford it, patients definitely can't afford it with paying it out of pocket and this is again where the doctors get frustrated because in lots of centres only 5 to 10 per cent will actually yield the result, most of the time, they are negative. So, people start thinking (…) why are we paying for these ridiculously expensive tests that takes five days to get a result back that's usually not even positive anyway, so, yeah, for this to work, I think, the costs have to radically come down in LMICs (low-to-middle-income countries), be much more like malaria where they say that, you know, we need to develop tests but they can't cost more than one dollar, end of story" (Interviewee III).

The out-of-pocket payment for laboratory testing can also be problematic as these tests do not always exactly show the resistant pathogens in the sample, and the results take a long time to be determined, particularly due to the unavailable laboratory infrastructures in some countries or regions. Therefore, the interviewee imagines a possibility of another testing, similar to another global health issue of

malaria, where the testing costs were brought down but this is still not the case for AMR. In addition, the current expensive AMR testing again comes back to the issue of representativeness, namely who can afford to be tested, whose samples are taken and recorded, and whose data finally ends up in the GLASS database and national, regional or global AMR estimates. Bringing down the costs of laboratory testing could be one of the ways to partly address the representativeness issue as well as strengthening the overall public laboratory capacities that could also bring down the costs required from the patients for their testing. However, such issues of testing costs and affordability are mainly invisible in the WHO´s publicly available documents on GLASS.

After data is collected on a surveillance site, sent to the laboratory, and the results are obtained, AMR data is envisioned to be reported to the WHO. However, data reporting to the GLASS and its standardisation is also differently performed in local contexts. One of the issues for reporting AMR data to the GLASS is that hospitals in various countries still collect and use paper-based patient data:

> "(…) for a lot of sites, they still have, for example, paper-based surveillance data, so for them, it's very difficult to get the data into the (WHO - GLASS) system" (Interviewee IV).

This means that even though hospitals collect samples from patients with a suspected infection and send them to the laboratories, they do not necessarily get the results back electronically as well as they do not store them in electronic patient data systems where this AMR data can then be easily aggregated and sent to the WHO and the GLASS. This could be common in lower-income countries or regions as told by one of the interviewees:

> "Electronic patient records are very uncommon, so everything is paper-based. The same is actually true for many laboratories still, people are writing things in big logbooks. So, to do any kind of surveillance, yeah, you need to sort out the data management side. That's really hard to do well" (Interviewee III).

Therefore, the requirement to submit AMR data to the WHO differently corresponds to the local contexts, especially in those who do not have the infrastructure to aggregate or collect data electronically. Currently, countries need to submit their AMR data for GLASS electronically via one of the platforms on the WHO´s website. However, if countries collect their data on paper, this could mean either not reporting their AMR data at all, or that there is additional data reporting labour needed from the persons transferring the collected data from the paper to the software, where human error is also possible. Similar to additional data collection labour and costs to the patients, additional data sharing labour is also not explored in the publicly available WHO documents.

Overall, the implementation of global GLASS standards for AMR surveillance along the lines of AMR data collection, testing, and sharing, creates a variety of frictions in clinical settings. Such issues usually manifest through unequal access to healthcare systems, infrastructures, and resources. Implementing

GLASS standards in clinical contexts often creates additional labour and costs in collecting and sharing AMR data which creates additional strains in the settings that already lack appropriate resources to implement responsive healthcare systems for all. For instance, AMR health burden estimations require additional data collection labour, particularly from the medical staff, as well as additional studies and it is unclear to what extent such resources are available in different countries and regions. Interviewees also reflected that these issues could create biased and unrepresentative AMR datasets which creates an issue for epidemiologists. In its documents, the WHO often reflects on the issues of data representativeness, however, the issues of additional data collection and sharing work as well as high costs carried by the patients for AMR laboratory testing are invisible in the publicly available GLASS documents as well as the potential limitations imposed for GLASS activities due to the differing local capabilities in clinical settings.

5.2.4. Expertise and negotiations within WHO on global AMR surveillance methodology

Next to AMR, the WHO has experience and expertise in other infectious diseases and their surveillance, for example, influenza, tuberculosis, HIV, malaria, or COVID-19. As presented in sub-section 5.1, such broad expertise provides WHO with the rationale of why it should coordinate and host the global AMR surveillance system. WHO documents also present that global AMR surveillance could potentially learn from the experiences of other global infectious diseases surveillance efforts driven by the WHO. However, the interviewees and WHO documents on GLASS reveal some resistance towards other internal approaches or expertise regarding the WHO´s suggested way of global AMR surveillance standardisation.

Although the WHO emphasises drawing from experiences from other diseases and their surveillance, one interviewee noticed that there can be resistance towards expertise from other diseases areas, such as tuberculosis (TB) that could be brought to the AMR surveillance field:

> "But tuberculosis has always been simply in a complete parallel universe when it comes talking about AMR. It's also funny… every time I talk with the microbiologists, and I put forward my experience from TB, they say that that is TB, that is something else… That feeling has a long time been with the WHO. It is now that they see the merit of looking back at what the WHO has been doing in the field of TB and how to take that knowledge forward to look into the future, how they can improve AMR surveillance systems" (Interviewee I)

Here, the interviewee draws a line between different expertise fields of microbiologists and epidemiologists and how they understand AMR in the face of infectious diseases, such as tuberculosis, and how some experience is not seen as relevant to AMR. However, the interviewee also expressed that

different expertise seems to start slowly influencing WHO´s AMR surveillance efforts in reflecting how they could be adjusted. Drawing from expertise in the tuberculosis field, the interviewee works on developing threshold surveys that could help to advance AMR surveillance, especially when most of the data comes from the samples from laboratories. Here, threshold surveys could provide additional information that is not as highly dependable on laboratory infrastructure. The interviewee explains the threshold surveys as:

> "Instead of saying that AMR is so many per cent for this drug and so many per cent for that drug (…) we're not interested in that at all. We are interested in whether or not AMR is so high that a certain antibiotic cannot be used. So, it is really a yes or no question. By changing that question, your number of patients drops considerably from the hundreds in the first approach to the 20, 30, 40 patients in the threshold surveys. Suddenly, it makes it very feasible even at the level of the facility (…) every decent facility can find 40 patients with urinary tract infections in two months. So, that means that you can do it much quicker, less people, by less costs, and the data is directly relevant for that institute. And then that institute can decide, okay, given my population and populations that come through my door, we should not give this antibiotic or still give this antibiotic even without testing. So, these are so called threshold surveys and you have different types of those surveys but we have been working with Lot Quality Assurance Sampling (LQAS)" (Interviewee I).

Overall, threshold surveys tell whether AMR is "high" or "low" according to the predefined threshold value (how many AMR cases are too high for a surveillance site), sample size (e.g., 40 patients as emphasised by the interviewee), infection type (e.g. urinary tract infections), and antibiotic(s) used to treat this infection in a particular hospital or another surveillance site. These measures would tell whether AMR is too high or low in a tested population. As explained above, this approach particularly concerns the use of antibiotics and the guidance for their prescription, for example, whether the doctors can prescribe a particular antibiotic or not if their resistance is increasing according to the results of the threshold survey.

Currently, the threshold survey approach is still in the research phase. The interviewee suggests that threshold surveys could be useful where laboratory surveillance of resistant pathogens raises issues:

> "It is now gathering evidence that this is the way forward if we see laboratory-based surveillance as potentially problematic for certain questions. So, it is really gathering the scientific methods that work. These threshold surveys are not new, they are from the 1960s and they have been used a lot in public health. In the health domain, they are used for monitoring implementations, like vaccination programmes, or training programmes. What we get is thinking whether or not that well-established method

> would answer questions in the AMR domain and we are strong believers that they answer questions (…) not every question but it answers some" (Interviewee I).

Therefore, threshold survey is a well-known method in the public health field which is still not applied for counting AMR. Interviewee envisions that some of the questions that threshold surveys could answer are the prescription of antibiotics based on the values of a population and not personal laboratory results. This approach mainly aims to address AMR by addressing the antibiotics consumption in the population which again corresponds to the common argumentation that AMR is mainly caused by antibiotic misuse and overuse. The interviewee also emphasises that threshold surveys are not meant to overtake laboratory-based surveillance. However, it still takes time to convince the WHO as well as other stakeholders, such as clinicians, of the threshold surveys´ benefits:

> "When we talk with the people from WHO, they are very reluctant, they were very reluctant, to talk about the population because it takes over their system that they have built for so long. But that's not the case, those are the different two pieces of information. Slowly, we see that the minds are… I don't want to say turning, but people start to see the merits of population-based surveillance and within that concept, it is very interesting to see whether or not such a quick threshold survey could take place. Because there is such a different way of thinking that especially clinicians have a problem. They want to know if it is a 10 per cent or 20 per cent or 70 per cent resistance. Then, we come and we say that the resistance is too high, that is not how the clinician thinks. So, our biggest challenge that we have is over the years is to come to a common ground and ask: why are you doing this surveillance and what do you want to get out of this. Sometimes, the method A and sometimes the method B will be better, depending on your question. I think that the problem that we have created is talking about THE surveillance system" (Interviewee I).

Here, the interviewee challenges the common thinking about the primary and only surveillance system, such as GLASS, instead of having multiple surveillance methods and experiences that could guide the understanding of AMR. In addition, as emphasised by the interviewee, surveys can also be resisted by clinicians who want to know the exact resistance rates in patients to treat them instead of making additional studies and surveys about AMR in populations which is a more common approach for epidemiologists and their work. Therefore, the interviewee emphasises that it is important to know what experts want to get out of surveillance and what questions they intend to answer. Knowing this could potentially help to understand what methods for AMR surveillance could work better.

To combine such different approaches in understanding AMR, its surveillance, surveillance outcomes, and, for instance, convince the WHO of threshold survey benefits, a lot of additional work is needed by persons who developed additional or alternative approaches. This negotiation work particularly

revolves around the point that surveys can be only complementary to laboratory-based pathogen surveillance, while laboratory-based surveillance should still remain at the centre:

> "Talking with the WHO, now they are slightly starting to see merits in them (threshold surveys) but it is a completely different way of thinking. That is more complicated than I anticipated, to convey the message that we are not throwing away your lab work, we are just adding the component that might give you a different angle and I think that is especially important for many infections that are treated empirically. The threshold-based survey in the intensive care unit, you don't need it. You have very good, you know, they send out seven specimens a day for their lab, so you don't need a threshold survey, just get data from the lab. But it is a different type of question" (Interviewee I).

The interviewee again emphasises the role and work done by the WHO and clinicians and that the threshold surveys are not intended to replace the current approach of the WHO and clinical work performed in the hospitals. Currently, in its modules, GLASS seems to incorporate the expertise and work practices of both, clinicians and epidemiologists, while epidemiologists' concerns, such as representativeness are mostly visible as they are repeated in almost all WHO´s documents on GLASS. While the laboratory work done for diagnostic purposes in the hospitals inform treatment decisions as well as forms the basis of AMR surveillance, the additional surveys and studies in the GLASS also aim to address epidemiological concerns on representativeness and collect additional data on populations. However, not all surveys coming from other infectious disease areas and their surveillance can make it to the GLASS modules, as shown by the example of threshold surveys. Therefore, the interviewee needs to convince the WHO about what questions threshold surveys could answer for AMR surveillance. However, as shown in the sections above, the WHO and other experts still do not have a concrete idea about what knowledge, what answers, and by whom could be accomplished with all AMR data collected by the GLASS and its different modules.

Despite all of the convincing labour done by the interviewee and their team, WHO briefly reflected on the use of threshold surveys in GLASS latest annual report. GLASS hints that the use of such different surveillance approaches can be complimentary, however, they allow national countries to decide themselves whether to use them or not "based on countries' needs and constraints, and the objective(s) to be achieved" (World Health Organization, 2021a, p. 160), where the voluntary participation aspect is emphasised again. Specifically, on threshold surveys, the WHO advises that:

> "This approach might be sufficient to guide empirical treatment decisions and for estimates of AMR in low morbidity, low mortality infectious syndromes, but it does not accurately measure the real magnitude of AMR in the population" (World Health Organization, 2021a, p. 161).

Interestingly, in the excerpts provided above, the interviewee contradicts this statement and tells that clinicians might not want to benefit from threshold surveys for empirical treatment decisions because "that is not how the clinician thinks". This again could refer to the lack of a clear vision by the WHO on what is aimed to be achieved at the end with all AMR data collected via the global surveillance, which stakeholders will actually use the data, create the knowledge, and what questions the data may answer at the end.

Overall, within the WHO and related experts, there are some negotiations about different infectious disease areas and surveillance methods that show some internal resistance of GLASS towards other surveillance methods coming from other disease and expertise areas. The suggested alternative or complementary approaches for AMR surveillance involve long negotiation work, while, once they are mentioned in the GLASS documents, they are presented more as an additional method to fill in the gaps from the laboratory-based pathogen surveillance. In addition, WHO presents these alternative AMR surveillance methods as something that countries should decide on their own. Therefore, the approach of testing resistant bacteria in laboratories remains the central method of GLASS global AMR surveillance standardisation. Such surveillance method suits clinical staff because laboratory testing, including the testing for AMR, is necessary for hospitals to diagnose the patients and assign an appropriate treatment. For GLASS, laboratory-based AMR testing is a core source for its global AMR surveillance, although other experts, such as epidemiologists within the WHO or outside of it, raise questions on AMR data representativeness, quality, and the need for broader population data. Even though some other approaches can be created to suggest how to overcome the issues of laboratory-based surveillance, alternative or complementary methods of surveys and studies face another problem of what is the overall goal of (global) AMR surveillance and what questions it should answer. As such visions are still quite vague, it is difficult to design fully alternative or complementary methods for global AMR surveillance, such as GLASS.

5.3. Dominant practices of the global in the AMR surveillance assemblage and resistance towards GLASS

5.3.1. Global AMR standardisation within the distinction of Global North and Global South: filling in the "knowledge gap" in lower-to-middle income countries

While presenting the global AMR surveillance and its standardisation, WHO often refers to groups of countries that implement the system as lower-to-middle-income countries (LMICs) and higher-income countries (HICs). This grouping follows the World Bank method of counting the countries' income levels (World Bank Group, n.d.). However, it is important to note that the World Bank changed the grouping of "countries" into "economies". Therefore, the World Bank now groups the countries as low-income economies, lower-middle-income economies, upper-middle-income economies, and high-

income economies. However, the latest WHO report still follows the grouping of countries according to their income levels (e.g., World Health Organization, 2021a) and this thesis will follow the older classification of HICs and LMICs as presented in the analysed WHO documents. WHO particularly compares LMICs and HICs in terms of the envisioned coordination needed over LMICs towards AMR response, showing the threat of AMR particularly in LMICs via global AMR surveillance, and lack of standardisation, laboratory infrastructures, and connectivity in LMICs.

In the WHO documents, the binary grouping between the LMICs and HICs allows the reader to see the differences between the AMR rates within these groups, the participation status in the GLASS, AMR data submission rates to the GLASS, as well as the capabilities and challenges within these groups relevant to their AMR surveillance systems. In the documents, LMICs are often seen as lacking the infrastructures and data on AMR rates which then results in knowledge gaps as carved out by the WHO. In this case, some of the interviewed stakeholders saw that the AMR response coordination by the WHO, including AMR surveillance and collecting AMR data from LMICs, is an important factor to counter AMR:

> "(…) WHO is really there to set norms and lead, especially (…) for low to middle-income countries because, without the WHO leadership, it's really hard for many of them to prioritise this kind of (AMR) issue" (Interviewee III).

Here, the WHO is perceived as a coordinator for AMR global response, while also bringing attention to and helping LMICs to prioritise the AMR as a global issue. Through this coordination, the interviewee further envisioned that the WHO could bring the benefit to LMICs through AMR surveillance:

> "(…) if we are able to show that in LMICs there are substantial numbers of people who are dying from AMR and that the drugs that they need are not affordable and accessible which is what's happening I think this would lead to much stronger global action to get these drugs at affordable prices where they are needed. Because (…) if you don't show that this is going on, then it's very easy for people to turn a blind eye to it" (Interviewee III).

Therefore, the interviewee envisions the WHO as not only leading AMR response, including surveillance but also it playing a role in drawing attention to the issue as well as setting priorities of the health issues in the global health field, particularly in LMICs. To this end, AMR data from the LMICs is needed to show high rates of AMR and enable global action by closing the knowledge gaps on AMR which could help to save people´s lives in LMICs. However, the interviewee´s argument to some extent contradicts the WHO´s and other experts´ claims that AMR is mostly caused by antibiotics misuse and overuse. In an LMIC setting, people could die from infectious diseases not only due to the resistant

pathogens but also due to the lack of access to drugs and lack of affordable pricing. Here, the data collection could also be beneficial to show this, as emphasised by the interviewee.

Once data is collected from the local contexts, it is then aggregated by the GLASS and presented in the form of reports as well as in the dashboard of the Global Health Observatory by WHO. So far, AMR data collected by the GLASS via laboratories not only provide information on global AMR rates but also present AMR rates on different national levels and provide an opportunity to compare different countries with each other. Such mapping efforts were outlined by one of the interviewees:

> "(…) the collection of data on all levels, including the Ears-Net, and the other regional, you know, you put it on the map and you do a lot of benchmarking, showing what countries can do (…) you do a stepwise approach, kind of looking at where the countries are in their process. I think this is important, this is also a type of benchmarking for countries to see (…) why AMR, why this country is doing so much better than ours, and so on" (Interviewee II).

This approach of AMR mapping is visibly indicated throughout the GLASS yearly reports. Each report presents 1-2 pages long cases of each country that submitted their AMR data to the GLASS. Although reports do not directly compare individual countries with each other regarding their AMR rates, the national graphs show the number of resistant pathogens in each country, thus, AMR level can be interpreted by the reader as well as which country does "better" or "worse" in their AMR rates. It is unclear though how the WHO interprets this data and whether it uses it for any purpose at this point, however, the storyline provided by the interviewee could refer to the analysis of AMR rates in different countries and why they potentially differ. Therefore, GLASS visualises the AMR data in its yearly reports country by country. Although the GLASS documents do not directly compare how countries are doing in managing their AMR rates, some broader comparisons are presented, particularly between the higher-income and lower-income countries.

As outlined in the section above, the issue with LMICs is not just the lack of AMR data but also a lack of data representativeness and quality – issues that are especially emphasised by the epidemiologists whose expertise is key in assembling GLASS as a global AMR surveillance system. One of the interviewees emphasised that the data in high-income countries is usually representative as sufficient patient samples are collected:

> "I think most high-income countries will have all the information and the data from some type of system (...) I think most of the data is there in high-income countries because they take a lot of samples and I think the representativeness will be fine in the high-income countries" (Interviewee II).

The interviewee perceived that high-income countries collect sufficient AMR data that can fit the global GLASS AMR surveillance standardisation. Meanwhile, the representativeness issue is perceived as

stemming from the black-boxed methodology of data collection, particularly in lower-income settings. Epidemiologists raise questions about the unknown methodology of how samples were collected in the hospitals or how they were tested in the laboratories in LMICs and whether the reported AMR rates to represent the national AMR situation:

> "For drug resistance, one of the important things is that sites have appropriate sampling guidelines, and they follow them up. Which is for high-income countries normally fine but as soon as you go to lower-income countries, that's much more difficult and we don't really know exactly what they're doing, who they're testing, often there's not enough resources, so we don't really know what they're reporting, how they have selected the labs that are reporting" (Interviewee III)

Therefore, the AMR data in LMICs can be perceived as not only lacking representativeness but also as black-boxed where the WHO and epidemiologists do not know how AMR data is collected, if at all. This may also show that most of the epidemiologists working for and shaping the GLASS come from higher-income settings. To this end, some of the GLASS data modules, such as BURDEN, EGASP and ONE HEALTH are piloted and conducted solely in the countries classified as lower-to-middle income (LMICs) and this could relate not only to the motivations to collect additional AMR data from the regions where laboratory and healthcare infrastructures are missing but also with the WHO´s potential goals to carve itself a space as a global coordinator of AMR data collection and response in LMICs.

The WHO perceives that a particular challenge in LMICs is the lack of infrastructures, such as laboratory infrastructures, to conduct AMR surveillance and produce quality AMR data. One of the interviewees emphasised the benefits of strengthening the laboratory surveillance which then improved the accessibility to testing and representativeness of AMR data as more people were able to get tested and not only ones who could afford it:

> "(…) strengthening the lab here where I'm working was not done for the goal of getting AMR surveillance data, it was more just to improve diagnosis in the country and start to uncover what were the important infections (…) and it's just kind of by-product of that you end up having of this AMR surveillance data over time and, I think, the fact that we were able to support the diagnosis free of charge meant you avoided a lot of bias that you see in other low to middle-income countries where people can't afford the tests freely and maybe some doctors think, oh, I'm not going bother and then they only take the blood culture or certain other specimen when their patient is not improving on a standard treatments. And then, if you do that, you end up biasing your population towards people who are more likely to have a drug-resistant infection that has failed conventional therapy" (Interviewee III).

Here, the interviewee works in one of the countries classified as LMIC and they mentioned the lab strengthening which was supported by the Fleming Fund's investment from the United Kingdom in the

same LMIC where the interviewee works. However, the interviewee also admitted that it is difficult to foresee whether such an investment from the outside, although beneficial, can be sustained in the future. In addition, such investments usually reach laboratories and hospitals in cities or "centres", leaving further regions outside of laboratory testing:

> "Fleming coming in in the last three years is transforming that, you know, we've just put five automated blood culture machines into provincial-level hospitals, so, we're still only talking about going down to city-province level, not below that, to district level" (Interviewee III).

Therefore, although WHO documents talk about the national countries and divide them into lower and higher-income ones, local settings can be more complex. AMR surveillance and its standardisation are mostly conducted in "centres" – usually capital city and surrounding areas or other bigger cities and it is unclear whether data from further regions or "peripheries" reach the GLASS at all or whether such data is at all intended to be included by the WHO while building the global AMR surveillance system.

In the documents as well as interviews the infrastructural gap between lower and high-income countries is foreseen to be closed primarily via the increased investment and political willingness for LMICs to follow the GLASS methodologies for AMR surveillance and coordination by the WHO. However, an existing and functioning laboratory, hospital, and IT system in higher income settings does not necessarily show that AMR data will be shared with the GLASS or that it will be representative. As one of the interviewees from the HIC in Europe highlighted:

> "So, WHO encourages people or countries to collaborate in GLASS surveillance. That is laboratory-based surveillance. If you have a very good system where all the laboratories send data nationally and those national data are then gathered centrally in the WHO, then you have something. But even here in (a European HIC country), we have a network of laboratory-based surveillance but until now not all microbiologists are attached to it, some just due to the simple IT problems. And even if you attach to it, you do not know why those samples end up in your laboratory: whether it is a new patient, a suspicion of resistance, is it because of treatment failure… so that makes the interpretation, even if you have a good surveillance system, difficult. Then you send everything to the GLASS that is also voluntary. So, you have to go bottom-up to the national and national systems decide what to put on and then you lose information along the whole line" (Interviewee I).

Therefore, even in the HIC in Europe, AMR data can be lost along the line, for instance, due to the IT issues in connecting laboratories; lack of patient information in the laboratories behind the patient sample; and a failure to report epidemiological AMR data to the WHO together with laboratory testing results. This story provided by the interviewee shows that AMR could be messy even in a HIC in Europe

with a relatively small population and that has been conducting various disease surveillance activities for decades now and still not as representative as wanted by the WHO.

Overall, the WHO often divides countries participating in the GLASS as LMICs (that could also be further divided into LICs or MICs) and HICs. The need for AMR surveillance in LMICs could often be justified through the need to close the "knowledge gap" on AMR and to save lives. This knowledge gap in LMICs is particularly formulated to be caused by the lack of AMR data and data representativeness issues stemming from missing laboratory infrastructures and expertise, particularly in lower-income regions. Here, more investment and following GLASS lead are envisioned as needed to solve these issues. However, the experience from higher-income regions also shows that AMR data can be collected rather sporadically and that different issues can occur in higher-income countries as well which can also lead to missing data and where the representativeness question can also be raised. In addition, as explored in the section above, although the data or knowledge gaps are envisioned to be closed, for instance, in LMICs, it is still unclear who will create the knowledge coming from the data collected, what other potential outcomes or interventions could come out of this data as well as when the sufficient AMR data will be collected from LMICs for the GLASS to be truly global.

5.3.2. One Health AMR data surveillance in the context of the dominant practices of AMR data collection in the human health domain

WHO recognises AMR threat as an issue not only for humans but also for animals and the broader environment (or as a threat for a One Health approach). However, WHO, while assembling GLASS as a global AMR surveillance system prioritises human health and counting bacteria as a main cause of AMR.

WHO documents see AMR threat as being caused by increasing antimicrobial consumption and "by transmission through increasing international movement of people, animals and food" (World Health Organization, 2014, p. 59), meaning that resistant bacteria can travel easier not only between animals and humans (e.g., due to the food consumption) but also because of easier travelling conditions for humans and global exchange of products. Although documents mostly emphasise the threat of AMR to humans and human health (World Health Organization, 2015b, p. 1; World Health Organization, 2018a, p. v) and repeatedly shape AMR as a public health threat (World Health Organization, 2020b, p. viii), over time, documents also start to put more emphasis on One Health approach. One Health approach includes not only human health but also animal and environmental health (World Health Organization, 2021a, p. 2). The latest GLASS yearly report of 2020 emphasises AMR surveillance in the environment, mostly in the wastewater:

> "Environmental reservoirs such as wastewater discharges from communities, health facilities and antimicrobial manufacturing sites and their downstream water bodies are

> known to contribute to the emergence and spread of AMR. The global action plans on AMR of both WHO and FAO recommend the development of techniques for environmental surveillance of AMR" (World Health Organization, 2020a, p. 112).

However, the current GLASS efforts on One Health are only at the exploratory or research level and not as broad as the GLASS-AMR module based on the samples collected from humans. One of the GLASS surveillance modules on AMR is called the "Integrated multi-sectoral surveillance" or ONE HEALTH. This module was established in 2018 to observe the resistant *E. Coli* bacteria in humans, animals and the environment (being tested in the sewage waters and water in the river in urban areas). The project currently runs in 14 lower-to-middle-income countries in Africa and Asia. The WHO´s extended methodology on this module is outlined in the document published in 2021 called the "WHO integrated global surveillance on ESBL-producing E. coli using a "One Health" approach: Implementation and opportunities" (World Health Organization, 2021c). The document also outlines what type of additional data it collects, for example, the description of the water from which the sample was collected (e.g., river, wastewater from humans or animals, the colour of the water, weather, and season during which the sample was collected, the speed of the water movement, and similar) (2021c, pp. 42-43). Overall, the document provides a clear methodology of how One Health surveillance can be conducted in a form of a protocol. However, the document also admits that for this surveillance, laboratory capacities are needed and would need to be expanded (2021c, p. 2). However, the WHO does not intend to conduct One Health surveillance on its own and it is shown by collaboration with other international organizations.

Although the Global Action Plan on AMR (World Health Organization, 2015) highlights the importance of the One Health approach and presents not only the logo of the WHO but also of the Food and Agriculture Organization (FAO) and the World Organisation for Animal Health (OIE), it remains unclear who is responsible for integrated One Health surveillance and its complexity, including the surveillance of bacteria from humans as well as from animals and the environment: whether it is all three or four organizations (including United Nations Environmental Programme), one of these organizations, or national countries or regions. It remains difficult to exactly pinpoint who is or plans to conduct One Health surveillance for AMR. Since 2010, the WHO, FAO and OIE formed a Tripartite dedicated to sharing the "responsibilities addressing health risks through multi-sectoral collaboration", meaning the collaboration between stakeholders in human, animal, and environmental health sectors (Food and Agriculture Organization, World Organisation for Animal Health, World Health Organisation, 2017, p. 2). However, such collaboration initially addressed not only AMR but also diseases that travel from animals to humans (zoonotic diseases), such as zoonotic influenza and rabies. The earlier documents of Tripartite include visions of coordinated surveillance systems between FAO, OIE, and WHO:

> "Strengthening and modernisation of the three Organizations' respective early warning and surveillance/monitoring systems and continued interlinking of these systems through the Global Early Warning System (GLEWS) to achieve situational awareness and coordinated joint risk assessment, risk management and risk communication" (Food and Agriculture Organization et al, 2017, p. 3).

However, currently, organisations in Tripartite did not establish a coordinated surveillance mechanism for AMR in One Health that would be similar to GLASS. One of the reasons for this could be that such surveillance efforts would be highly complex. The more current achievement of Tripartite is the release of their definition of One Health as "an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems" (a broader definition is provided in (Food and Agriculture Organization, World Organisation for Animal Health, World Health Organisation, et al, 2021, p. 1). Although the updated definition addresses broader society, climate change, and sustainable development, it does not allude to the need or a vision for surveillance. On their own, the WHO documents recognise the complexity of One Health surveillance, where the prioritisation of particular bacteria and cost-effectiveness is needed because of such complexity:

> "How do we implement One Health surveillance effectively for AMR in this complex livestock/human/ecosystem interface? Surveillance needs to be prioritized and cost-effective - it is not feasible to conduct surveillance in all sectors and it will be context dependent" (World Health Organization, 2016a, p. 24).

Although the feasibility of One Health surveillance is challenging and GLASS currently clearly prioritises human health, it is also taking small steps towards One Health surveillance integration. One of the interviewed stakeholders sees GLASS efforts as having potential towards One Health surveillance integration:

> "But what can be done and what this encourages is more setting up a multisectoral coordination mechanism in countries in implementing national action plan, including surveillance. But for the data itself collected can be difficult and then it's more of a joint analysis when it comes to the One Health. But I think for this, the GLASS is looking more into the collaboration with the… within the Tripartite and UNEP (United Nations Environment Programme)" (Interviewee II).

Therefore, One Health surveillance is presented as quite complex and even not entirely feasible, while the responsibility is shared with other actors, such as FAO, OIE, and UNEP. However, currently, there are no clear indications of how integrated One Health AMR surveillance could work methodologically or who should be responsible for its implementation. At this moment, the GLASS and WHO seem to be encouraging countries to figure out and integrate One Health AMR surveillance more independently and their progress in this area are not tracked. Meanwhile, the GLASS ONE HEALTH module is piloted

in some lower-income countries. Another interviewed stakeholder working in LMIC stated that some external funding is available to the country‘s national animal health laboratory, however, One Health surveillance efforts, especially in lower-income countries are still in the inception phase:

> “Not so much happening routinely in the environment and you know, we’ve been involved in research looking to water screening and so on. So, I think, you know, it is starting (...) it’s really hard to put it all together because (...) some research now looks into transmission from animals to humans. Yes, it's not that obvious that it (AMR) is coming through food production. So maybe more environmental contamination (...) it’ll just take some time to work out the optimal way, I think, to do this“ (Interviewee III).

Therefore, even if One Health surveillance is piloted in some countries, stakeholders might still not be convinced or have a vision of how such surveillance could be carried out at all. Although the WHO presents the ONE HEALTH module, it does not rush to take on the full responsibility of One Health surveillance and is rather sharing it between different organizations under the UN umbrella. Therefore, GLASS is assembled mostly as a human health AMR surveillance system.

The WHO also primarily focuses on AMR caused by bacteria, while slowly starting to incorporate other resistant organisms, such as fungi. Another focused AMR surveillance activity of the GLASS involves the GLASS-FUNGI module. This module focuses on the AMR data collection on fungal infections and there is a growing resistance towards antifungal medicine. In this module, GLASS particularly focuses on the pathogen of Candida spp that can cause yeast infections and is perceived as one of the more common causes of fungal infections. GLASS perceives that only few countries are conducting surveillance and observing the resistance of this pathogen globally. The surveillance of fungi pathogens, such as the Candida spp is also done through the laboratory methods, such as antifungal susceptibility testing (AFST).

In 2019, the WHO released a document on Candida fungi species (spp) surveillance called the “Early implementation protocol for Inclusion of Candida spp“ (World Health Organization, 2019b). The main rationale of the document is to draw the public eye´s attention towards the fungi that “are also major causes of human disease and death, and resistance to antifungal medications is a growing problem, as it is for antibiotic drugs“ (2019b, p. 7) which is similar to the AMR threat presented by bacteria as shaped by the WHO. The document encourages countries to include and build capacities for the Candida spp next to other GLASS priority pathogen global surveillance. The document particularly emphasises the collection of Candida spp data based on bloodstream infections because they are “cause for concern as these are severe infections with high mortality rates“ (2019b, p. 8).

At the same time, the surveillance of fungi presents additional requirements and expertise, next to the resistant bacteria surveillance. This module also builds on the need for laboratory and healthcare

infrastructures, similar to other WHO AMR data collection practices as discussed above. In addition, to include Candida spp in the collected data, national laboratories "should have expertise in methods for characterizing antimicrobial-resistant fungal pathogens" (World Health Organization, 2019b, p. 15). The WHO document admits that such expertise can be limited in some of the countries and therefore suggests establishing Candida reference centres (CRCs) in each of the WHO regions to provide training for national laboratories and additional information about the antifungal susceptibility testing (AFST) as well as help to submit this data to the GLASS (2019b, p. 16). Currently, not all countries participating in GLASS submit their data on resistant fungi and this method is still being presented as a "pilot" in 26 countries, mainly in the countries of Central and South America (World Health Organization, 2021c, p. 59). In addition, the current work of GLASS-FUNGI data collection is also seen as an information source for the research and development agenda of the WHO and was used during the "First Meeting of the WHO antifungal expert group on identifying priority fungal pathogens" in 2020 (2021, p. 147).

Overall, the WHO places a primary emphasis on human health and assumes the responsibility for AMR surveillance in humans. Nevertheless, it also participates in the Tripartite efforts for One Health surveillance. However, the secondary focus of the WHO still goes to AMR in animals and the environment, while a vision for optimal and global surveillance of AMR in the integrated One Health field is placed and hoped for in the future. Although the Global Action Plan on AMR that confirmed the GLASS establishment emphasised the importance of the One Health approach, surveillance in all domains – human, animal, and environmental – is currently not present. While national countries are encouraged to implement AMR surveillance in all domains, WHO currently positions GLASS mainly as a human health-focused surveillance system. Unlike AMR surveillance in humans, the WHO is not as quick to pronounce itself as a leading coordinator in this field. Instead, the responsibility is shared between the Tripartite of the WHO, FAO, OIE, and the UNEP, while the actual efforts of surveillance depend on countries' capabilities of infrastructure and expertise. GLASS also prioritises resistance in bacteria. GLASS modules such as GLASS-FUNGI are only in their inception at specialising in a specific antifungal-resistant pathogen of *Candida spp* whose surveillance is still new for many countries and is only being tested by the WHO. Similar to the other resistant bacteria prioritised by the WHO, *Candida spp* are also shaped as presenting a high threat and mortality rates to humans, however, the volume of data collected on bacteria by countries and presented by GLASS show that fungi resistance is currently not as visible and prioritised.

5.3.3. External visions and expertise on standardizing global AMR surveillance

In the global health field, there are other visions of how the WHO´s visions on global AMR surveillance and different modules of the GLASS could be implemented. Other efforts are conducting parallel work to the GLASS, while not directly collaborating and feeding their data or results to the WHO´s global

AMR surveillance system of GLASS. Although there are some platforms online that also aim to collect AMR data mainly based on laboratory testing and other additional patient information (e.g., Pathogen.watch; HealthMap ResistanceOpen; Antimicrobial Testing Leadership and Surveillance), GLASS is still seen as the biggest AMR data collector in the global health field at the moment based on many samples submitted to it yearly. However, some efforts show resistance, intentional or not, to the current GLASS methodology which mainly relates to AMR health burden estimation studies and routine AMR surveillance. In addition, other WHO member states can also show resistance by not participating in GLASS efforts, although they have existing AMR surveillance systems and where they share AMR data with other regional surveillance systems.

One of the more prominent efforts that emerged during the interviews in the context of this thesis concerned AMR health burden estimations. The Institute of Health Metrics and Evaluation (IHME) in the United States started conducting AMR health burden estimations some years ago with the latest publication of Murray, Ikuta, Sharara et al (2022). While GLASS is working on the BURDEN module on AMR health burden estimations, the IHME published their own study looking at AMR health burden globally following a different methodology than GLASS. One of the interviewees explained the methodology behind the study that differs from the GLASS-suggested AMR health burden estimation protocol:

> "(…) their (IHME) starting point is something that they call death certificates (…) So they have access to these kind of registries, so they start by looking at, okay, why did this patient die and, I mean, it's tricky because you can only die of one reason, so if somebody has, I don't know, diabetes and a drug-resistant infection, what do they write on the certificate? Do they say it was drug-resistant infection or do they say diabetes? So you're going to miss some things there but they extracted all the patients that died of some kind of infectious syndrome" (Interviewee IV).

The interviewee briefly overviews the study and its starting point of death certificates which differs from the GLASS BURDEN module which advises following patients for 28 days after they are diagnosed with a resistant infection in the hospital. The interviewee explained that instead of following the patient, the IHME study used modelling and predictions of AMR mortality to estimate how many patients died because of various infections in different countries. Despite different methodologies, the interviewee saw that the IHME study succumbs to similar methodological challenges as the ones in the protocol on AMR health burden estimations suggested by the GLASS due to the difficulties to assign one and the primary reason for death when people had different difficult conditions, such as diabetes and resistant infection.

The interviewee further contemplated the WHO's role in the global AMR health burden estimation field next to the work already conducted by IHME on a large scale, while the WHO is still piloting the AMR

health burden estimations. The interviewee´s story revolved around how the WHO can still contribute to the AMR health burden field:

> "(..) the question now really is, okay, if they already did this, what is the role of the WHO still. One of the things is that this Lancet study show that there's very little real data from low-income countries about attributable mortality and that's one of the things they need in their models to calculate how many people died. And actually, WHO could fill that hole if it would be implemented in low to middle-income countries because then you get this attributable mortality estimates which you can use to then calculate how many people die. So, in that sense, it could also be complimentary but I'm afraid that there's actually not a lot of collaboration between the people who work in this Lancet study and WHO" (Interviewee IV)

Therefore, there is a potential use for the WHO's AMR health burden studies, such as to calculate it in lower-income regions. Currently, the GLASS BURDEN module is particularly piloted in the lower-income regions, although such a decision was taken before the IHME study was released. Further collaboration opportunities between IHME and the WHO in the area of global health burden estimations are unclear to the interviewee and not mentioned in the publicly accessible WHO documents. It is also unclear whether IHME will not conduct such estimations as well and faster than the WHO and the GLASS BURDEN module.

Therefore, as mentioned in the sections above, although the WHO positions itself as a coordinator for global AMR surveillance efforts and other AMR responses, including AMR health burden estimations, some other global initiatives, like IHME, can resist being coordinated, and follow their methodology on how to count AMR. The more visible reasons for such resistance can emerge due to the changes in funding sources as well as experts that gain a particular source of funding and, due to personal reasons, decide to move around with it between different institutions:

> "(…) the Global Burden of Disease Studies was actually something that was done at WHO at the start. At the certain point in time (…) it actually moved out of WHO because the person who worked on it actually moved to another institute in the United States (…) And that same person has now been working on burden on AMR from this independent institute and they've got a lot of funding to do that, while WHO felt that they were actually in the best place to work on these kind of things but they didn't get any funding to work on it. So that's been a bit of a difficult situation, really" (Interviewee IV).

As also alluded to by the interviewee, the Global Burden of Disease Studies first emerged in the 1990s under the World Bank, and several years later it was institutionalised by the WHO. However, since 2013, Global Burden of Disease Studies moved under the IHME after gaining significant funding from

Bill and Melinda Gates Foundation (IHME, 2022). However, before that, Global Burden of Disease Studies significantly influenced the WHO´s understanding of global health burden, including AMR, as Global Burden Disease Studies first introduced the disability-adjusted life year (DALY) under the World Bank – a measure that is still currently used by the WHO and is envisioned to be used in the future for AMR global health burden estimates. As highlighted by the interviewee above, currently the WHO and IHME do not collaborate in calculating the AMR health burden estimates nor do IHME studies follow the pilot methodology of the GLASS in this area. Therefore, IHME stands as one of the examples that resist WHO and GLASS methodology for global AMR surveillance, however, this is largely invisible in the publicly available documents.

Other smaller and more independent AMR surveillance efforts are led by academics, clinicians, or pharmaceutical companies and are not coordinated or intend to be coordinated and collaborate with the WHO. The examples of such efforts are already mentioned in the State of the Art section and above, namely, Pathogen.watch (led by academics and based on national funding); HealthMap ResistanceOpen (led by clinicians); or Antimicrobial Testing Leadership and Surveillance (led by a pharmaceutical company of Pfizer). However, smaller and more independent AMR surveillance efforts succumb to challenges as well, mainly related to their long-term sustainability. One of the interviewees has worked on the mapping of AMR surveillance efforts globally and noticed that:

> "If you go back over the years, there have been networks, several networks, set up which may be focused on one bacteria for a few years and then the funding runs out and it collapses (…) there are quite many of those around but in general they've all died out (…) just seeing these, how uncoordinated these initiatives have been and how they come and then they go, yeah, it's a bit of the waste of the resources. But there have been many academic ones (…) I think that's really common (…) if you think how academics work as well (…) they see the funding call, they go for it, and then they set up a nice website and then (…) it all just dies off" (Interviewee III).

Therefore, the interviewee sees further issues with the lack of coordination of AMR efforts as well as issues of finding funding and how to sustain the storage of the collected AMR data and study results. As discussed in the sections above, the WHO sees itself as a coordinator for global AMR responses, including surveillance, however, the GLASS also shows similarities to the sustainability issues of smaller efforts, as GLASS sees the funding from national countries and political willingness as a key aspect to maintaining its further activities for global AMR surveillance.

There are no indications whether GLASS can coordinate external AMR surveillance activities that are outside of national governments´ reach, for instance, the ones developed by academics, pharmaceutical companies, or simply other initiatives that might work on their methodology, such as IHME studies. As one of the interviewees emphasised, GLASS AMR surveillance coordination work concerns national

countries and their commitment to AMR surveillance via the national action plans that have to be submitted to the WHO:

> "(…) I mean, this is outside of GLASS, of course, but there's a lot of initiatives ongoing. I think it took a while when you build GLASS to really understand different initiatives and really make everyone accepting GLASS and seeing this as the one system. But even today, I would say, apart from funding, the coordination of primarily supporting countries in implementing GLASS and implementing the national action plans" (Interviewee II).

Therefore, GLASS primarily concerns surveillance within countries and their commitments to the WHO to compile global AMR surveillance. This type of global AMR surveillance includes specific actors on the national level, such as political bodies, clinicians, and laboratory staff, while other stakeholders on the same national level are not visible imagined, for instance, civil organisations or patients. To this end, other data collection efforts that might encompass more than one country, alternative methodologies, and stakeholders are currently not visible in the global AMR surveillance vision of GLASS. At the same time, although mentioned by the interviewee, it is also not entirely clear to what extent other external initiatives have accepted GLASS as the "one and global" surveillance system as plenty of AMR surveillance efforts still continue in parallel that can also be called global. However, some interviewees saw that if data from other data collection initiatives were shared with GLASS, it might create further biases and challenges:

> "(…) if all these pharmaceutical organisations suddenly dumped all their data into GLASS, it's really hard to know how helpful that would be in terms of, you know, what if they were only studying people who had skin infections or (…) urinary infections" (Interviewee III).

Therefore, additional AMR data collection efforts are seen as potentially creating biases for global AMR surveillance. As highlighted by the interviewee, for instance, if more studies focus on a particular pathogen or a particular infectious disease. This again refers to the representativeness issue raised by the epidemiologists where, due to the data collection bias, AMR could be understood as too high or too low than it actually is in the population. Despite these methodological concerns, another challenge for the WHO could be to track and convince all of these different stakeholders and their data collection initiatives to share the AMR data with the GLASS as it is even difficult to do with some of the national countries that collect AMR data but do not necessarily share it with the GLASS. However, such challenges or potential inclusion of other stakeholders is not mentioned in the WHO´s documents on GLASS. GLASS is mainly assembled as a global AMR surveillance system through national countries and the power of national or regional governments, including health ministries and other public health bodies.

However, although GLASS is strongly constituted of national countries and their willingness to participate, some of the countries that possess surveillance capabilities envisioned by the GLASS, still do not submit their data to the WHO´s global AMR surveillance system. Looking through the GLASS reports, one such clear example is Denmark which has been conducting national AMR surveillance activities since the 1990s (DANMAP, n.d.). Danish AMR surveillance system provides its data to the EARS-Net system, while Denmark also has produced a National Action Plan against AMR that was submitted to the WHO (Ministry of Environment and Food of Denmark & Ministry of Health, 2017). However, DANMAP does not participate in GLASS activities. Publicly available documents, neither by the GLASS nor by the DANMAP provide answers, to why the Danish AMR surveillance system is not involved. A similar situation can be observed with other European countries that submit their data to EARS-Net but do not participate in the GLASS, according to the latest GLASS annual report, for instance, Spain, Portugal, Estonia, Slovakia, Hungary, Romania, and Bulgaria (World Health Organization, 2021a, p. 4). Similar to Denmark, the publicly available sources, either by the WHO or by the national countries' surveillance initiatives that are available in English, do not discuss why data is submitted to the European AMR surveillance system of EARS-Net and not to the GLASS as well as other countries´ non-participation which is, in the end, based on a voluntary participation principle.

Overall, to various degrees, GLASS is resisted externally in its different AMR surveillance modules by smaller or bigger initiatives that collect data and study AMR more independently. Currently, clearer examples of resistance to GLASS methodology occurs within global AMR health burden estimations, pathogen surveillance based on laboratory testing, and studies on different pathogens and infectious diseases. External resistance to the GLASS stems from different funding sources, expertise, different methodologies, or national unwillingness to participate in GLASS activities. In such cases, the WHO experiences resistance towards its role as a coordinator of global AMR efforts, including global AMR surveillance carried out by the GLASS. However, such resistance is quite invisible in the WHO documents. Other additional efforts are not referred to or discussed by the WHO, despite their potential benefits or additional challenges that could be faced by the GLASS due to the competing methodologies in global AMR surveillance.

6. Discussion

The empirical analysis outlined above showed that the WHO assembles the Global Antimicrobial Resistance and Use Surveillance System (GLASS) via its navigation through embedded power relations in the global health field as well as knowledge and standardisation practices. The assemblage of the GLASS by the WHO corresponds to the entanglement of global health regimes of global health security regime and humanitarian biomedicine (Lakoff, 2017). Within these regimes, WHO presents different ways of navigating embedded power relations and knowledge practices while assembling GLASS, such as emphasising AMR threat and preparedness, emphasising own role as a coordinator and collaborator,

and highlighting the expertise of laboratories, epidemiologists, and clinicians. The assemblage of the GLASS also corresponds to the standardisation (Timmermans & Epstein, 2010) efforts, while making some practices more visible and prioritized than other practices.

- **Navigation through embedded power relations in the global health field**

Regarding the navigation of embedded power relations in the global health field, while assembling GLASS, WHO navigated both global health regimes: the global health security regime as well as the humanitarian biomedicine (Lakoff, 2017). In this way, the WHO assembles GLASS via the understanding of AMR as a global threat and countries needing to prepare and protect themselves against increasingly resistant bacteria, while also emphasising the need to save lives as well as to ensure more positive health and economic outcomes in the future.

The global health security regime is mostly emphasised by the WHO via the AMR threat. On the global level, the World Health Assembly (WHA) and World Health Organization (WHO) rationalise the establishment of the GLASS with an emphasis on the AMR threat. Before and during the establishment of the GLASS, WHO highlights AMR threat through a variety of future projections and calculations on how much AMR can cost in the future, particularly to the economy and its effects on human health, such as death, disability, and prolonged hospital stay. Within a global health security regime, countries´ security depends not only on a lack of conflict but also on the global health situation, when infectious diseases do not correspond to countries´ borders and can cause broader negative effects, such as for health, economy, countries´ reputation, and similar. To prepare for such global health threats, global surveillance systems "provide early warning of potential outbreaks and link such early warning systems of rapid response designed to protect against their spread to the rest of the world" (Lakoff, 2017, p. 72). Chandler (2019) emphasises that AMR is more successfully stabilised through sentinel devices that "treat unprecedented diseases that cannot be mapped over time but can only be anticipated and prepared for" (Lakoff, 2015a, p. 40). Therefore, the understanding of AMR as a threat as well as urging to prepare for AMR threat helps the WHO to pool the support of international organizations, countries, and high political figures to support the cause of AMR and its global surveillance.

Although the WHO presents AMR as a threat to all, it starts to assemble global initiatives, such as GLASS, at a high political level. While assembling GLASS, the WHO shapes itself as a coordinator for global AMR surveillance and its standardisation. This corresponds to the research of Brown, Cueto & Fee (2006, p. 62) who observe that since the beginning of the 21st century, the WHO "began to refashion itself as the coordinator, strategic planner, and leader of global health initiatives as a strategy of survival in response to this transformed international political context" following the shift from the understandings of "international health" to "global health". The WHO especially needed to carve this role for itself with the proliferation of other global organizations and funds dedicated to global health, where the WHO is "merely one of many major global health security organizations in an increasingly

crowded field" (Hoffman, 2010, p. 515). Therefore, the WHO uses a variety of knowledge practices and ways how to navigate the embedded power relations in the global health field to assemble itself as a coordinator for global AMR response, including the assemblage of the global AMR surveillance system of GLASS.

In the AMR field, the WHO assembles the GLASS through its previous experience in AMR and disease surveillance and through the support of organisations at a high political level. On one hand, WHO assembles its role from its previous work on AMR when, in the early 2000s, it framed the AMR strategy as "global" which also coincides with the emerging understanding of "global health" at the end beginning of the 21st century (McInnes & Lee, 2012). On the other hand, WHO is continuously supported by a number of higher-income countries as well as other international organizations, such as the United Nations in coordinating and setting up the standards for AMR response. However, WHO envisions the responsibility of implementing standards to be carried out by the national countries and regions in their own local contexts. National or local governments are assigned the responsibility from the "global" surveillance body to communicate and share health data: "Individual governments are given the responsibility of not only the surveillance and containment of infectious diseases, but also, crucially, of communicating to a larger international community" (Mahajan, 2021, p. 208). While in the national context, the standardisation of AMR surveillance coordinator is again a higher political body, such as the ministry of health or a public health agency, implementation of AMR data standardisation is directly carried out by the medical staff in hospitals, laboratory technicians, persons translating and submitting local AMR data into the GLASS, as well as persons from whom samples for AMR data is collected.

- **Knowledge practices in assembling GLASS as a global AMR surveillance system**

The WHO assembles GLASS while prioritizing the future calculations of AMR risks and especially through the epidemiological thought style, laboratory-based AMR surveillance, and the collection of additional epidemiological data about AMR.

This thesis shows that in the case of the WHO and GLASS, sentinel devices, such as calculating the future costs of AMR threat, can further be used to stabilise actuarial devices (mapping of "disease over time and across populations to gauge and mitigate risk"), such as performed by the GLASS AMR surveillance. In this case, sentinel devices of future AMR threat projections help to carve out the global need for GLASS surveillance via laboratory-based methods and additional epidemiological data. However, GLASS is not solely built on the understanding of AMR threat and global health security regime – many of its modules for global AMR surveillance also correspond to the epidemiological thought style (Reubi, 2018).

GLASS day-to-day activities are mostly shaped via the understanding and calculations of AMR that is pertinent to epidemiological expertise and epidemiological thought style. One of the key stakeholder

groups involved in the formulation of global AMR surveillance via GLASS is epidemiologists. The WHO assembles GLASS through epidemiological thought style and its key cornerstones: “the will to save lives, the belief in the importance of data, social surveys, epidemiologists and global population” (Reubi, 2018, p. 87). One of the beliefs under this thought style is that the diligent collection and analysis of data is important to save lives, for example, through epidemiological surveillance (2018, p. 84). This data collection is particularly associated with epidemiologists as this is how they are trained and how they work (Reubi, 2018, p. 85). The current GLASS surveys and studies collect additional health information that is not always available via laboratory testing, such as the patient's age, health history, details on the hospital stay, and similar. This corresponds to the epidemiological thought style where epidemiologists “shift from vital statistics and their interest in the environment to the social survey and its concern with lifestyles“ (Reubi, 2018, p. 93). This is noticeable not only in the additional GLASS modules on antibiotics consumption but also in the other surveys and studies, for example, with the surveillance of Neisseria gonorrhoeae pathogen where patients are also asked to provide additional information about their travel and sexual history together with their samples tested in laboratories.

The WHO also aims to collect data on the global AMR health burden. Wahlberg and Rose explore the shift of the epidemiological thought style from the “compilation and tabulation of vital statistics – death rates, birth rates, morbidity rates – contributed to the birth of the ‘population’ in the eighteenth and nineteenth centuries” to the changes starting in the mid-20th century, where the “death gives way to that of morbid living, made calculable through a metrics of ‘severity’, ‘disability’ and ‘impairment’” (Wahlberg and Rose, 2015, p. 60). Such measures include Quality Adjusted Life Years (QALYs) and Disability-adjusted life years (DALYs). Adams (2016, p. 27) also distinguishes between calculating DALYs in Global North and Global South: “In the Global North what mattered was counting the cost of keeping people alive, whereas in the Global South what mattered was plausible justification for continued expenditures in relation to death and disease burdens”. Here, “DALY was useful in cost-effectiveness debates and for helping groups like the WHO to determine overall disease burden from specific problems like HIV/AIDS, malaria, and TB on a global scale, which, in turn, justified ongoing health aid investments as problems of global scope”.

Although currently, GLASS studies AMR health burden by mortality, a long-term vision is to implement and standardise a methodology that could show DALYs caused by AMR. Such calculations could further show negative AMR impacts, and threats, and emphasise the need for AMR surveillance standardisation and its global implementation, such as GLASS. Overall, by collecting AMR data via different modules, the WHO envisions the knowledge production that is supposed to create potential understandings, solutions, and interventions for AMR that may save human lives in the future which corresponds to the epidemiologists´ thought style. Although AMR is shaped as a global issue with one of the potential interventions being AMR surveillance, the discourse of saving lives in the WHO

documents on GLASS particularly revolves around regions and countries perceived as lower-to-middle-income.

Therefore, the WHO´s intervention of GLASS which conducts global AMR surveillance balances the two global health regimes. On one hand, GLASS is based on the global AMR threat and the need to monitor and prepare to handle the resistant bacteria globally which corresponds to the global health security regime. One of the strategies for tackling AMR is global AMR surveillance that is based on the pre-existing efforts on AMR and other diseases by collecting human samples and testing them in the laboratories for pathogens. On the other hand, GLASS modules emphasise the collection of epidemiological data that provide additional information about the patient with a resistant infection, particularly in the countries and regions perceived to be lower income (LMICs). GLASS modules on surveys and studies that particularly focus on epidemiological data collection show that these efforts are mostly focused on LMICs as they often do not possess the required laboratory infrastructures for envisioned GLASS AMR surveillance. This also corresponds to the global health regime of humanitarian biomedicine as AMR data collection efforts focus on "failure of development", "lack of access to health care", and diseases that affect lower-income regions (Lakoff, 2017, p. 73). This shows that global health regimes (Lakoff, 2017) are broader paradigms that shape how AMR is thought about, enacted, and what solutions are envisioned to solve AMR on a global scale. In the case of assembling GLASS, different modules to varying extents embrace both of the global health regimes. This shows not only the complexity of AMR as a phenomenon but also how it affects the assemblage of its global solution, such as GLASS, as it aims to combine all of the global health regimes in its assemblage.

- **Standardisation as a tool to assemble GLASS as a global AMR surveillance system**

The WHO balances both global health regimes while assembling GLASS as a global AMR surveillance system. However, to be truly global, GLASS has to standardize and align the remaining regional and national AMR surveillance systems according to the WHO´s preferred methodology. GLASS shows different levels of standardisation in the WHO´s efforts to standardize it as a global AMR surveillance system, following the standardisation phases of "creation, implementation and resistance, and outcomes" (Timmermans & Epstein, 2010). Timmermans and Epstein (2010, pp. 75-77) argue that the standards are set up and created collectively, while some actors need to be convinced of their implementation. To this end, WHO convinces and shapes the need for GLASS implementation and AMR surveillance standardisation through AMR global threat, especially emphasising this threat to human health and the (global) economy. This corresponds to Brown and Nettleton's (2017) research that looked at how the understanding of AMR is constructed in public discourses and narratives. They found that AMR was often described through metaphors as the "impending apocalypse" or the "return to the dark ages of medicine" which is also similarly used in the WHO documents to raise public and especially political concern and awareness on AMR threat.

Timmermans & Epstein (2010) further argue that the standards are usually created for the public interests, however, the public usually does not directly participate in their creation. However, before and after the establishment of the GLASS, the wider publics and patients from whom the AMR data is collected, are addressed vaguely. WHO created the GLASS and AMR surveillance standardisation to solve the AMR threat globally, however, there are only particular groups involved in such standards creation. As explored by Asdal (2015, p. 77) "Turning something into an issue might also imply that it becomes, in certain important ways, a non-issue; a question to be handled exclusively by certain issue experts, excluding persons or groups with an interest". Although AMR is a broad issue that is depicted to affect all, patients that are affected by AMR and from whom samples are collected via AMR surveillance as well as other relevant stakeholders, such as their patients´ families or relatives, are rarely addressed in the assemblage of the GLASS. Instead, one of the central actors in GLASS assemblage as a global AMR surveillance system is WHO, which envisions the stakeholders that directly participate in GLASS primarily to be national governments, clinicians, laboratory staff, and other relevant experts, such as epidemiologists.

Regarding the implementation of GLASS, the WHO acknowledges the differences in infrastructures required for (AMR) surveillance and their connectivity to the global AMR surveillance carried out by GLASS. Therefore, WHO allows flexible participation in the GLASS. Timmermans and Epstein argue that flexibility is an important aspect of the standardisation success as well as trust in the local practices and capabilities: "The trick in standardisation appears to be to find a balance between flexibility and rigidity and to trust users with the right amount of agency to keep a standard sufficiently uniform for the task at hand" (Timmermans & Epstein, 2010, p. 81). To this end, the implementation of global GLASS AMR surveillance standards is flexible and voluntary. This means that countries are free to collect AMR data that they need for their own goals and choose (not) to report this data to the GLASS or what data (not) to report. Such flexibility can be seen as a way to involve more countries to participate in the GLASS and convince them to implement GLASS AMR data surveillance standardisation by their means. However, WHO cannot implement mandatory AMR surveillance standardisation on a global, national or local level due to the lack of legislation in the global health field and also due to the difficulties to define AMR (i.e., what bacteria should be measured and what not). Although such voluntary AMR surveillance implementation allows flexibility in local contexts, it also means that countries or regions might prioritise and dedicate their resources to other diseases, emergencies, and fields.

The implementation of GLASS is also challenged or even resisted. As explored by Timmermans and Epstein (2010), standards are often resisted in their implementation stage. The WHO´s global AMR surveillance standardisation is not straightforward and the WHO experiences challenges with its global AMR surveillance standards assemblage from the inside as well as the outside. Internal questioning on the WHO´s methodology for AMR surveillance stems within the WHO and experts responsible for

other surveillance methods, for example, tuberculosis. However, for this internal resistance, the WHO has more control over the alternatives suggested for AMR surveillance approaches as GLASS can control to what extent they make alternatives visible in their publicly available documents and website. Usually, other internally suggested methods for AMR surveillance involve long negotiation work, while, once they are made visible in the documents, they are presented more as alternatives to fill in the gaps of the global laboratory-based pathogen surveillance, while the countries can choose voluntarily whether to apply alternative AMR surveillance methods or not. Therefore, the approach of testing resistant bacteria in laboratories remains a central method of GLASS as a global AMR surveillance standardisation system, despite a number of challenges. Even though some other approaches can be created to suggest how to overcome the issues of laboratory-based surveillance, these methods face problems of what is the overall goal of AMR surveillance and what questions it should answer in global and local contexts. On the other hand, although WHO placed itself as a coordinator of AMR surveillance standards on a global level, other external AMR data collection endeavours work in parallel with the GLASS and resist following its standardisation methods.

External resistance occurs based on different funding sources, expertise, different AMR data collection and analysis methodologies, or national resistance to participate in GLASS AMR surveillance standardisation. As explored by Stephenson (2011) in the case of Indonesia´s withdrawal from the WHO´s "virus-sharing" scheme, resistance by national countries could be understood as "a distinct form of biological sovereignty in the form of rival global health security aggregates, each working to inject a new form of postliberal sovereignty into the field of global public health" (p. 616). Although it is difficult to tell whether the non-participation in the GLASS is caused by the countries´ enactment of their sovereignty or is mostly caused due to the lack of capabilities and different health priorities, currently this external resistance remains invisible in the WHO documents as well as in other broader global health resources. In the case of Indonesia´s withdrawal from the „virus-sharing" scheme, this discourse was more visible as being broadly discussed by the media. Although Indonesia has signed IHR and was expected to share its samples with the global community, the "WHO's response has not involved an attempt to invoke international treaties or law, but the intensification of its role in consolidating partnerships that constitute the response to global health crises as a matter for global assemblages that include a myriad of actors not traditionally involved in international health governance" (Stephenson, 2011, p. 622). For global AMR surveillance, the WHO does not have a legal basis, such as IHR to make countries share their AMR data, nor does the WHO visibly engage with other actors, such as the pharmaceutical companies, in sharing GLASS data for antibiotics research and development yet. Meanwhile, the non-participation of the GLASS and the reasons for it remain largely invisible from the public discourse.

Similar to resistance, other local issues are made more invisible by the publicly available documents of the WHO. As Timmermans and Epstein argue, once standards are established, they often render the

local knowledge and capabilities invisible: “Once standards are established, they render invisible the work required to make them possible and the uncertainty and ad hoc tinkering that accompanied standard implementation. The power of standardisation lies exactly in how such local erasure allows new manipulations to take places such as calculation and commodification” (2010, p. 83). In some ways, WHO still struggles to reach the invisibility of the local practices and knowledge for the global GLASS implementation, for instance, missing healthcare or laboratory infrastructures and expertise that is particularly assigned to the regions perceived as lower income. However, WHO makes other local aspects of global AMR surveillance implementation invisible more successfully, for instance, the data labour for collecting and reporting local AMR data to a global GLASS system. Such local data labour appears to be invisible in the WHO documents that do not reflect on how the limited capabilities for additional data labour can influence the GLASS implementation in local contexts.

WHO aims to assemble GLASS as a global infrastructure for AMR surveillance, where “infrastructure occurs when the tension between local and global is resolved” (Star & Ruhleder, 1996, p. 6). For this, national countries are mainly expected to align their AMR surveillance with GLASS methodology or to build laboratories as well as other capacities in the first place. Due to the lack of data and infrastructures in regions perceived as lower income, a perception of a knowledge gap on AMR emerges. Therefore, global actors, such as the WHO expect some regions to “catch up” with the required infrastructures to enable global AMR surveillance as the lack of infrastructures can be seen as presenting obstacles of “incomplete integration into the modern projects of total surveillance and seamless exchange” (King, 2002, p. 782) on a global level. WHO documents and interviewed stakeholders often emphasised that one of the solutions to solve the issues of the lack of AMR surveillance connection is increased funding for the technical development of surveillance infrastructures in lower-income regions. However, even currently established AMR surveillance systems that are being standardised for 30 years now, face the issues of “seamless exchange”. For instance, the main issues on the European AMR surveillance (EARS-Net) are seen to be structural (differing objectives, lack of data sharing coordination, standardisation, and missing food surveillance data), laboratory-based (insufficient data and biases in collecting samples), and lacking “coordination between human, animal, and food systems” (Tacconelli et al, 2018, p. 103). The methodology of laboratory-based surveillance is also criticised as it uses only clinical samples and that it is “not likely to be useful as an early warning system for emerging pathogens and resistance mechanisms” (Tacconelli et al, 2018, p. 99). Despite AMR being shaped as a global health threat concerning all, the WHO documents and some researchers argue that the burden of AMR is distributed unevenly between the Global North and the Global South, or between the high-income countries and lower- and middle-income countries (Littmann & Viens, 2015).

Despite numerous challenges experienced by already existing AMR surveillance systems that fit the vision of WHO´s global AMR surveillance, laboratory-based AMR surveillance is still perceived to be needed in countries classified as low-to-middle-income. There is still a gap in infrastructure because of

the “weak laboratory capacity, poor health systems governance, lack of health information systems, and limited resources” (Iskandar, Molinier, Hallit, et al, 2021). However, only investing in building surveillance infrastructure, such as laboratories, might not bring sought-after results for global surveillance (Mahajan, 2021, p. 208). Although countries can receive funding from external donors to build a surveillance system, it does not mean that they will find further funding to sustain it in the long term, for instance, to pay wages for the laboratory staff, as such surveillance systems need to be embedded into functioning healthcare and other infrastructures and cannot exist on their own based on one-time external donation (as explored by Maxmen, 2021). In addition, Mahajan (2021, p. 208) points out that “Building these capacities of surveillance and containment inevitably involves choices and trade-offs”, where the countries might have different priorities for the use of their limited funds, such as investing in the overall healthcare and scientific infrastructures, including the training of requires specialists, instead of solely focusing on building and enabling pathogen testing for AMR in the laboratories.

As Rushton (2011, pp. 793-794) argues, there is “nothing inherently wrong with attempting to limit the international spread of infectious diseases“. However, it is important to note that the costs and benefits of such surveillance efforts are not always shared equally, as, based on “global” data, including the data from lower-income settings, higher-income countries can develop medicines and vaccines faster that will also be distributed in these regions first, while lower-income countries often wait longer for these medical solutions. One of the examples of such practice occurred when “(…) Indonesia has withdrawn from the World Health Organization’s (WHO) ‘‘virus-sharing’’ scheme because WHO has facilitated the use of Indonesian samples of H5N1 for the commercial development of potentially profitable vaccines without consultation with the Indonesian labs in which they originated” (Stephenson, 2011, p. 616). This example shows that although countries might share their health data that could be highly useful for medical interventions, such as vaccine development as explored by Stephenson (2011) in the case of Indonesia´s resistance to the WHO´s health data sharing, countries, especially the ones perceived as lower income, are not sure whether they will benefit from the medical intervention created from their data shared as medical interventions are usually first developed and distributed in the countries and regions classified as higher-income. The same applies to antibiotics as currently many countries, especially ones classified as lower income, lack access to them (Baekkeskov et al, 2020, p. 2), despite a dominant discourse that AMR is mainly caused due to the antibiotics misuse and overuse, while mostly concentrating on human use and less so on animal use.

Other less discussed aspects include the visions and opinions of healthcare staff who are assigned the responsibility to collect AMR data in their local settings. Mahajan (2021) argues that the COVID-19 pandemic showed that in the case of the global health emergency, the primary respondents are healthcare facilities and healthcare professionals: “COVID-19 has revealed that many countries that do a good job of routine health care across the population are likely to be in a stronger position for

emergency-time pandemic care, too. It creates the imperative that global health security not be conceptualised as exclusively about emerging infectious diseases; rather, it should be integrated with broader matters of health systems" (2021, p. 211). This shows the importance of broader healthcare infrastructures and the expertise of healthcare staff that are needed to address global health emergencies, instead of solely focusing on laboratories and epidemiological data collection that are currently prioritized by the WHO in the assemblage of the GLASS.

Beyond the human element in the assemblage of AMR surveillance, the One Health approach that aims to encompass sectors of human, animal, and environmental health is not as prioritised by the WHO while assembling the global AMR surveillance system of GLASS. Although the WHO is conducting some of the pilot efforts in One Health surveillance via its ONE HEALTH module which is implemented in countries perceived as lower-income in Asia and Africa, these efforts are not as broad as routine AMR surveillance based on the collection and testing of human samples from the hospitals. As shown by the empirical analysis of WHO documents and interviews, challenges for One Health surveillance stem from the lack of clarity of who should be responsible and coordinate such efforts (i.e., is it the WHO, Tripartite, national countries/regions), methodological unclarities of how to collect One Health AMR data, and lack of technical capabilities. This corresponds to the challenges observed in the current research efforts that show One Health (OH) surveillance is challenging due to the: "(...) lack of a conceptual and methodological framework which would (i) define the characteristics of OH surveillance, and (ii) identify the appropriate mechanisms for inter-sectoral and multi-disciplinary collaboration, to ensure that the surveillance system performs well, with regard to the objective, the context and the health hazard under surveillance" (Bordier, Uea-Anuwong, Binot, et al, 2020). Some of the research efforts are already aiming to better define the characteristics of One Health and what stakeholders should be involved (e.g. Ghai, Wallace, Kile, et al, 2022), while in 2017, the European Commission a European One Health Action Plan against Antimicrobial Resistance (AMR) which aims to make the EU "a best practice region", including the AMR surveillance (European Commission, 2017). Overall, the current research on AMR shows that the One Health framework is still in the inception of being implemented to understand and tackle AMR (e.g., Chandler, 2019), especially globally. This thesis also shows only initial considerations and efforts by the WHO towards the One Health framework in AMR surveillance as well as including resistant fungi, while many unclarities remain and are postponed to the future once the questions of technology, methodology, and responsibility are resolved.

In the outcome stage (Timmermans & Epstein, 2010), although one of the key cornerstones of the GLASS is to produce the knowledge to inform the possible solutions on AMR at global, national, or regional levels, there are still no concrete visions on what knowledge should be created out of all the global AMR data collected as well as who should produce this knowledge. The current phase of the intensive data collection could be seen as "promissory" because the benefits of this process are

envisioned to occur in the future, once enough data is collected (Hoeyer, 2019), although it is not clear when is it going to be enough data. Such responsibility again seems to be shifted to national countries or more local environments, such as political bodies or research organizations. WHO documents and interviewed stakeholders, mostly with epidemiological expertise, envision some potential interventions based on GLASS data corresponding to the currently popular discourses about AMR solutions. These visions for solutions involve reducing antimicrobial use in global and local contexts as well as prioritising the development of new antibiotics and new medicinal products.

Overall, WHO shows different levels of success while standardizing GLASS. The global health security regime (Lakoff, 2017) is particularly visible in the creation of the GLASS and its standards due to the WHO´s discourse on AMR threat and preparedness. However, the implementation of the GLASS can be resisted, although such resistance is not visible in the publicly available documents as well as the more specific challenges experienced by the local sites and stakeholders who implement GLASS methodology. The envisioned outcome of the GLASS then falls under the humanitarian biomedicine regime, especially since the collected data by the GLASS can potentially inform knowledge on the creation of new antibiotics that are also needed for the lower-income regions. However, the overall broader inequalities in the lack of access to antibiotics in LMICs are not discussed in the GLASS documents.

The empirical analysis of the publicly available WHO documents and expert interviews as well as existing research on the topics of global health, AMR, and surveillance, show complex intertwinement between different global health regimes and standardisation practices that occur while WHO assembles GLASS as a global AMR surveillance system. WHO assembles GLASS while navigating the embedded power relations in the global health field and knowledge practices between two different health regimes of global health security regime and humanitarian biomedicine (Lakoff, 2017). On one hand, GLASS aims to map AMR spread globally which is perceived as a global health threat as well as close knowledge gaps in the regions where such mapping has not been carried out before to create knowledge that could help to mitigate AMR globally and save lives. However, the WHO activities in assembling the global AMR surveillance still fall under the global health security regime (Lakoff, 2017), where the fear by the "global North" of cross-border infections leads to the need for the "global South" to build up laboratory infrastructures and comply with AMR data collection standards (Timmermans & Epstein, 2010) as envisioned by the WHO. Such different political interests as well as prioritised knowledge practices do not leave space for the local concerns and capabilities that are also often left out or not prioritised in the publicly available WHO discourses.

Meanwhile, the standardisation of the GLASS, as well as GLASS efforts to standardise other regional and national AMR surveillance systems, reveal complexities between global and local dimensions. The standardisation methodology by the GLASS emphasises the knowledge and expertise of laboratories, epidemiologists, and samples collected in the clinical sites, other more local practices and resistance

remain largely invisible or not prioritised in the publicly available WHO documents discussing AMR surveillance standardisation. Although the WHO documents present challenges for AMR surveillance and their connection that are also common in the countries and regions that are perceived as "higher-income", WHO documents still mainly emphasise infrastructural challenges in LMICs. To this end, the global health understanding of the division between the "global North" and "global South" cannot be reduced to the challenges of AMR surveillance, such as missing capabilities, infrastructures, and lack of representative data in the regions perceived as lower income as the local settings can be much more complex. The global health divide between the global North and global South is similarly criticised by Adams, Behague, Caduff et al (2019), where: "rather than assuming that global health will always work to rectify the great divide between North and South, we might insist on figuring out what the actual conditions are in the places where global health gets done, including how knowledge, wealth, and health circulate, how poverty is constituted and experienced, and who and what are already working to solve these issues, if anyone" (p. 1393). The standardisation efforts by the WHO again present the intertwinement and complexity of the global health regime while assembling global AMR surveillance. While the global health security regime (Lakoff, 2017) is visible while creating and implementing GLASS, such as using the rationale of AMR threat and preparedness, the humanitarian biomedicine regime is also visible in the visions of GLASS outcomes, such as knowledge and research that could help to create new antibiotics.

7. Conclusion

In this thesis, I explored the research question of how the WHO assembles the "global" in the global health field by navigating the embedded power relations in the global health field and knowledge practices while assembling the Global Antimicrobial Resistance and Use Surveillance System (GLASS). This question was informed by the qualitative analysis of publicly available WHO documents on the GLASS and four qualitative expert interviews with persons who are involved in AMR surveillance on national and/or regional levels and who are also familiar with the GLASS activities. The results presented in this thesis were also based on the theoretical understandings of the global assemblages (e.g. Collier, 2006), global health regimes (Lakoff, 2017) and standardisation (Timmermans & Epstein, 2010).

Regarding the navigation of embedded power practices in the global health field, the WHO assembles GLASS via the rationale of AMR threat and the need for preparedness. This is based on the global health security regime (Lakoff, 2017) and the emphasis on the need for surveillance on national and global levels. The WHO carves its role in GLASS assemblage by emphasising its work in the field of AMR, its expertise in disease surveillance and global health crises. However, the WHO still navigates a variety of embedded power dynamics in the global health field while assembling GLASS, for instance, by assembling GLASS from the top to bottom (WHO as a global AMR surveillance coordinator, mostly

for the lower-income countries) and bottom-up (WHO as a collaborator for global AMR surveillance, mostly with higher income countries that already have existing AMR surveillance systems and expertise). This shows that in the global health field and the governance of the perceived global health threats, such as AMR, there is not one clear stakeholder who would lead the response towards it. Instead, the stakeholders such as the WHO navigate complex embedded power relations in the global health field between the different national countries and international organisations that possess their interests, such as the concerns for infectious disease spread, national security, and the need for surveillance. Therefore, in this case, Science and Technology Studies (STS) approaches help to sensitize how the global approaches to global health threats, such as AMR, are assembled, and how they are shaped by the power relations in the global health field. One of the key differences in power relations shown in this thesis emerges between the countries perceived as higher-income and the lower-income, where the higher-income countries are perceived as the ones assembling the solution for a global health threat, while the lower-income countries are perceived as a source for infectious disease threat and as a place where solutions, such as surveillance, need to be implemented.

While assembling GLASS, WHO also emphasises specific knowledge practices and expertise, mostly coming from laboratories, epidemiologists, and clinical sites that should help to map AMR globally. Currently, the WHO is conducting routine and focused AMR surveillance that is mostly based on antimicrobial susceptibility testing (AST). However, via GLASS, the WHO emphasises the collection of additional epidemiological patient data via surveys and studies, particularly in lower-income settings, where infectious disease surveillance is not built yet. GLASS global assemblage shows that WHO aims to map AMR spread globally which is perceived as a global health threat as well as close knowledge gaps in the regions where such mapping has not been carried out before, such as in regions perceived as low-income to create knowledge that could help to mitigate AMR globally. Although such intentions could be understood via the perspective of humanitarian biomedicine (Lakoff, 2017) to create new knowledge and new interventions for antibiotic resistance as well as to save lives following the epidemiological thought style (Reubi, 2018), the WHO´s activities in assembling the global AMR surveillance still fall under the global health security regime (Lakoff, 2017), where the fear by the "global North" of cross-border infections leads to the need for the "global South" to build up infrastructures and comply with AMR data collection standards outlined by the WHO. Overall, the sensitizing concept of the global health regimes (Lakoff, 2017) shows that global health security and humanitarian biomedicine are broader paradigms that shape how AMR is thought about, enacted, and what solutions are envisioned to solve AMR on a global scale. This shows not only the complexity of AMR as a phenomenon in comparison to a single infectious disease but also how it affects the assemblage of its global solution, such as GLASS, as GLASS aims to combine both of the global health regimes in its assemblage.

The WHO also navigates the assemblage of the GLASS through standardisation practices, aiming to standardize currently existing AMR surveillance systems according to the WHO´s methodology through GLASS as well as to convince stakeholders to build such systems where they do not exist. However, such standardisation efforts also show what types of stakeholders, experts, and data collection practices are prioritised, what is left out, or where the points of resistance emerge. While the WHO prioritises AMR surveillance based on laboratories infrastructures, epidemiological expertise, rationales coming from higher-income countries, and AMR data collected about humans, the WHO´s visions of global AMR surveillance often do not emphasise the local concerns, capabilities, and needs, such as the additional and unpaid data labour required from healthcare staff to collect and epidemiologically representative AMR data globally as well as national or global resistances towards GLASS. Overall, the prioritization practices of the WHO show how the understanding of global health threats, such as AMR, are based on selective, constantly evolving, and contested practices of data collection standardisation, surveillance, and knowledge production. Despite these challenges, WHO´s standardisation practices show that some tensions that are associated with the global AMR surveillance are left invisible and not discussed in publicly available sources.

Overall, this thesis mainly focuses on the topics of global health and the global health threat of AMR and one of its envisioned solutions –global surveillance. In this thesis, I aimed to show how these topics can be explored through STS sensitizing concepts of global assemblages (Collier, 2006), global health regimes (Lakoff, 2017), and understanding of standardisation (Timmermans & Epstein, 2010). Overall, these understandings of STS in this thesis help not only to de-construct the GLASS and how the WHO assembles it as a global AMR surveillance system but also to navigate what practices in the global assemblages are held as self-evident, such as "what kinds of assumptions, what kinds of familiar, unchallenged, unconsidered modes of thought the practices that we accept rest" (Foucault, 1988, p. 154). Therefore, STS approaches open questions and discussions about how these practices could be performed differently and more openly by looking at how specific ways of collecting, sharing, analysing, and building infrastructures for "global" data and knowledge shape and is shaped by embedded power relations in the global health field within and between geographic domains, such as Global North and Global South, between epistemic domains, such as epidemiological expertise in comparison to clinical or other experiences by the publics and the patients, as well as the complex entanglement between the global and the local practices.

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Appendix 1. Abstract

Since the mid-2010s antimicrobial resistance (AMR) started gaining prominence as a global health threat at a high political level. The World Health Organization (WHO) named it an "apocalyptic" global health threat, where a "post-antibiotic era—in which common infections and minor injuries can kill" and that it is "far from being an apocalyptic fantasy, is instead a very real possibility for the 21st century" (World Health Organization, 2014, p. IX). One of the solutions to counter such threats as shown in the WHO documents is to collect knowledge via global surveillance efforts. Therefore, focusing on global initiatives that generate data and knowledge on AMR, in this thesis, I ask *how does the WHO assemble "global" in global health via its knowledge practices and within embedded power relations in the global health field* while looking at the case of the Global Antimicrobial Resistance and Use Surveillance System (GLASS). Following the understanding of global health assemblage (e.g., Collier, 2006), global health regimes (Lakoff, 2017) and standardisation (Timmermans & Epstein, 2010), this thesis intends to explore what is made visible and prioritized in the global health field while assembling global solutions to global threats, such as AMR, as well as what challenges, complexities, and resistances are left out of the publicly accessible discourses. This exploration of GLASS through the sensitizing concepts from the Science and Technology Studies (STS) field can help not only to de-construct the GLASS and how the WHO assembles it as a global AMR surveillance system but also to open the questions and discussions about how these practices could be performed differently and more openly by looking at how specific ways of collecting, sharing, analysing, and building infrastructures for "global" data and knowledge shape and is shaped by embedded power relations in the global health field as well as the knowledge production practices.

Corresponding to increased attention to AMR, the WHO established the GLASS in 2015. GLASS aims to standardize the currently existing AMR data collection, analysis, and sharing systems on a global level to obtain knowledge on AMR as well as to coordinate the establishment of infrastructures required to collect AMR data that would correspond to the GLASS methodology. As outlined in the GLASS website, WHO envisions this knowledge and evidence to inform policy decisions about AMR on national, regional, and global levels. These efforts include the WHO´s endeavours to navigate complex power relations between different stakeholders in the global health field as well as different expertise and knowledge of how the GLASS should be assembled as a global surveillance system. The standardisation practices of the GLASS-enabled surveillance allow seeing what is visible and prioritized in a global assemblage, for instance, which stakeholders, expertise, and data collection practices. Similarly, the standardisation practices of the WHO also allow exploring further what is left out of the global assemblage of the GLASS, for instance, what stakeholders, expertise, data collection practices, complexities, and resistances.

To answer my research question, I have qualitatively analysed publicly available WHO documents on the GLASS as well as conducted four qualitative expert interviews with persons who are involved in AMR surveillance on national and/or regional levels and are familiar with the GLASS activities and the WHO. I argue that, while assembling GLASS as a global AMR surveillance system, the WHO uses the rationale of AMR threat and preparedness, while taking the roles of a global AMR surveillance coordinator and collaborator. My empirical analysis further shows that some expertise, methodologies, countries and regions, as well as health domains, are prioritised more than others while assembling a global AMR surveillance system. The WHO´s visions for global AMR data collection mainly include aspects that AMR data should come from laboratories, include additional epidemiological information about patients, be representative, represent One Health paradigm (including AMR in animals and environment), and come equally from both envisioned higher- and lower-income regions. However, GLASS is shaped by different interests within and outside of the WHO as well as different interests and understandings about AMR. On the one hand, GLASS aims to map AMR spread globally which is perceived as a global health threat as well as close knowledge gaps in the regions where such mapping has not been carried out before to create knowledge that could help to mitigate AMR. On the other hand, GLASS activities fall under the global health security regime (Lakoff, 2017), where the fear by the "global North" of cross-border infections leads to the need for the "global South" to build up infrastructures and compliance with AMR data collection standards. Therefore, GLASS standardisation efforts (Timmermans & Epstein, 2010) of AMR surveillance globally are complicated because there are different interests and different priorities caught in different meanings of "global health" and AMR. Such high-level standardisation of GLASS and concerns about health security and the knowledge gap do not leave space for local concerns and capabilities as well as the national and global resistances towards GLASS as a global AMR surveillance system.

Zusammenfassung

Antimikrobielle Resistenzen (AMR) haben als globale Gesundheitsbedrohung auf hoher politischer Ebene seit Mitte der 2010er Jahre an Bedeutung gewonnen. Die Weltgesundheitsorganisation (WHO) hält sie für eine "apokalyptische" globale Gesundheitsbedrohung, in der ein *„Post-Antibiotika-Zeitalter, in dem gewöhnliche Infektionen und kleinere Verletzungen tödlich sein können"*, die „*weit von einer apokalyptischen Fantasie entfernt ist, sondern eine sehr reale Möglichkeit für das 21. Jahrhundert darstellt*". Eine der Möglichkeiten, mit diesen Bedrohungen umzugehen, wie sie in den Dokumenten der WHO beschrieben wird, ist sie zu Überwachen. Folglich konzentriere ich mich in dieser Arbeit auf globale Initiativen, die Daten und Wissen über AMR generieren und frage, wie die WHO das "Globale" in der globalen Gesundheit durch ihre Wissenspraktiken und innerhalb der eingebetteten Machtverhältnisse in der globalen Gesundheit zusammenfügt, indem ich den Fall des *Global Antimicrobial Resistance and Use Surveillance System* (GLASS) untersuche. Aufbauend auf dem Verständnis von *Global Health Assemblages* (z.B. Collier, 2006), *Global Health Regimes* (Lakoff,

2017) und *Standardization* (Timmermans & Epstein, 2010) wird in dieser Arbeit untersucht, was im Bereich Global Health sichtbar gemacht und priorisiert wird, während globale Lösungen für globale Bedrohungen wie AMR erarbeitet und welche Herausforderungen, Komplexitäten und Widerstände in den öffentlichen Diskursen ausgeklammert werden.

Angesichts des wachsenden Interesses an Antimikrobielle Resistenzen hat die WHO 2015 *GLASS* ins Leben gerufen. Ziel von *GLASS* ist die Standardisierung der derzeit bestehenden Systeme zur Erfassung, Analyse und zum Austausch von Daten über Antibiotikaresistenzen auf globaler Ebene, die Gewinnung von Erkenntnissen über Antibiotikaresistenzen und die Koordinierung des Aufbaus von Infrastrukturen, die für die Erfassung von Daten über Antibiotikaresistenzen gemäß der *GLASS-Methodik* erforderlich sind. Die WHO möchte dieses Wissen und diese Erkenntnisse für politische Entscheidungen über AMR auf nationaler, regionaler und globaler Ebene nutzen, wie auf der Webseite von *GLASS* erklärt wird. Aus diesem Grund arbeitet die WHO an der Standardisierung von *GLASS*. Diese Bemühungen schließen die Anstrengungen der WHO ein, mit den komplexen Machtverhältnissen zwischen den verschiedenen Akteuren im Bereich der globalen Gesundheit sowie mit den unterschiedlichen Fachkenntnissen und dem unterschiedlichen Wissen darüber, wie *GLASS* als globales Überwachungssystem aufgebaut werden sollte, umzugehen. Die Standardisierungspraktiken der auf *GLASS* basierenden Überwachung ermöglichen es, zu sehen, was in einem globalen Datensatz sichtbar ist und Priorität hat. Dazu gehören z.B. die Interessengruppen, die Expertise und die Datenerhebungspraktiken. Ebenso ermöglichen die Standardisierungspraktiken der WHO zu untersuchen, was in der globalen Ansammlung von *GLASS* übersehen wird, z.B. welche Interessengruppen, Fachkenntnisse, Datenerhebungspraktiken, Komplexitäten und Widerstände.

Zur Beantwortung dieser Frage habe ich eine qualitative Analyse öffentlich verfügbarer WHO-Dokumente zu *GLASS* sowie vier qualitative Experteninterviews mit Personen durchgeführt, die auf nationaler und/oder regionaler Ebene an der Überwachung von Antibiotikaresistenzen beteiligt und mit den *GLASS-Aktivitäten* und der WHO vertraut sind. Bei der Entwicklung von *GLASS* als weltweites Überwachungssystem für Antibiotikaresistenzen wird die WHO die Rolle eines weltweiten Koordinators und Akteurs für die Überwachung von Antibiotikaresistenzen übernehmen. Aus meiner empirischen Analyse geht auch hervor, dass einige Fachgebiete, Methoden, Länder und Regionen sowie Bereiche des Gesundheitswesens bei der Entwicklung eines globalen Überwachungssystems für Antibiotikaresistenzen eine höhere Priorität haben als andere.

Die Vision der WHO für ein weltweites AMR-Datenerfassungssystem umfasst insbesondere die Aspekte, dass AMR-Daten laborbasiert sein sollten, zusätzliche epidemiologische Informationen über Patienten enthalten sollten, repräsentativ sein sollten, das Paradigma einer einzigen Gesundheitsversorgung (einschließlich AMR bei Tieren und in der Umwelt) widerspiegeln sollten und gleichermaßen aus Regionen mit hohem und niedrigem Einkommen stammen sollten. Die Arbeit von *GLASS* wird jedoch von unterschiedlichen Interessen innerhalb und außerhalb der WHO sowie von

unterschiedlichen Interessen und Auffassungen in Bezug auf Antibiotikaresistenzen beeinflusst. Auf der einen Seite zielt *GLASS* darauf ab, die weltweite Verbreitung von AMR, die als globale Gesundheitsbedrohung wahrgenommen wird, zu kartieren und Wissenslücken in Regionen zu schließen, in denen eine solche Kartierung noch nicht durchgeführt wurde, um Wissen zu schaffen, das zur Eindämmung von AMR beitragen kann. Auf der anderen Seite sind die *GLASS-Aktivitäten* Teil des *Global Health Regimes* (Lakoff, 2017). Dabei führt die Angst des "globalen Nordens" vor grenzüberschreitenden Infektionen dazu, dass der "globale Süden" Infrastrukturen aufbauen und Standards für die Erfassung von AMR-Daten einhalten muss. Aus diesem Grund sind die Bemühungen von *GLASS* um eine *Standardization* (Timmermans & Epstein, 2010) der globalen Überwachung von Antibiotikaresistenzen kompliziert, da es unterschiedliche Interessen und Prioritäten gibt, die sich in den unterschiedlichen Bedeutungen von "globaler Gesundheit" und Antibiotikaresistenzen widerspiegeln. Eine solche Standardisierung auf hoher politischer Ebene und die Sorge um die Gesundheitssicherheit und die Wissenslücke lassen keinen Raum für lokale Belange und Fähigkeiten, wie z. B. der Mangel an Gesundheits- und Laborinfrastruktur, die zusätzliche und unbezahlte Arbeit des Gesundheitspersonals, die für die Erhebung epidemiologisch repräsentativer AMR-Daten erforderlich ist, die sich überschneidenden Probleme und die komplexeren Fähigkeiten der Länder, die Unterscheidung zwischen Regionen mit hohem und niedrigem Einkommen, die Priorisierung der menschlichen Gesundheit anstelle einer "One-Health"-Überwachung und die Priorisierung resistenter Bakterien gegenüber anderen resistenten Organismen wie Pilzen. Im Rahmen dieser Arbeit wird deutlich, wie eine globale Gesundheitsinitiative – i.d.F. *GLASS* - im Bereich der globalen Gesundheit aufgebaut ist, was priorisiert oder nicht erkannt wird, sowie die Komplexität, die konkurrierenden Interessen und das Fachwissen, die involviert sind und priorisiert werden.

Appendix 2. Categories and themes derived from the empirical analysis

Categorite from coding	Themes in the analysis
• AMR burden estimations • AMR surveillance practices: actuarial devices • AMR surveillance practices: Sentinel devices • AMR surveillance practices: other • Coordination • Collaboration • AMR surveillance challenges • Needs for GLASS to function • Participation motivation: voluntary/ mandatory • Rationale of AMR surveillance/GLASS • Standardisation • Threat of AMR • Visions about GLASS future • AMR comparison to other diseases • AMR surveillance data sharing • AMR surveillance methodology • AMR surveillance outcomes • Complexity/multiplicity of AMR • Different/competing expertise • National commitment/willingness • Other AMR surveillance efforts/initiatives	Differing visions, capabilities, and competing expertise in global AMR surveillance and standardisation: WHO, laboratories, epidemiologists, and clinicians
• AMR surveillance challenges • Rationale of AMR surveillance • AMR surveillance methodology • Complexity/multiplicity of AMR • One Health	Visions of One Health AMR data surveillance in the context of the dominant practices of the AMR data collection in human health domain
• AMR surveillance challenges • Coordination • HICs and LMICs • Key messages from AMR surveillance • Rationale of AMR surveillance • AMR surveillance data sharing • AMR surveillance methodology • Complexity/multiplicity of AMR • National AMR surveillance system	Global AMR data collection in Global North and Global South: filling the “knowledge gap” in lower-to-middle income countries

Appendix 3. Analysed documents list

Author	Name	Publication Year	Length of the document (PDF pages)	Parts / pages coded
World Health Organization	Global Antimicrobial Resistance Surveillance System (GLASS). Technical Meeting on the Early Implementation Phase	2015	44	Executive summary and full proceedings (30 pages)
World Health Organization	Global Antimicrobial Resistance Surveillance System Manual for Early Implementation	2015	44	Sections 1 – 3 (22 pages)
World Health Organization	Global Antimicrobial Resistance Surveillance System (GLASS). Report of the meeting of the WHO Global Collaborating Centres to support AMR activities globally	2016	41	Executive summary and full proceedings (30 pages)
World Health Organization	Diagnostic stewardship. A guide to implementation in antimicrobial resistance surveillance sites	2016	27	The whole document (27 pages)
World Health Organization	Global Antimicrobial Resistance Surveillance System (GLASS). Guide to preparing aggregated antimicrobial resistance data files	2016	38	Sections 1 – 8 (18 pages)
World Health Organization	Global Antimicrobial Resistance Surveillance System (GLASS). Guide to uploading aggregated	2016	23	The whole document (23 pages)

Author	Name	Publication Year	Length of the document (PDF pages)	Parts / pages coded
	antimicrobial resistance data			
World Health Organization	Global Antimicrobial Resistance Surveillance System (GLASS). Implementation questionnaire	2016	6	The whole document (6 pages)
World Health Organization	Report of the 2nd Meeting of the Global AMR Surveillance System (GLASS) Collaborative Platform	2016	63	Summary report and full proceedings (49 pages)
World Health Organization	Global Antimicrobial Resistance Surveillance System (GLASS). Guide to enrolment for antimicrobial resistance national focal points	2016	8	The whole document (8 pages)
World Health Organization	GLASS EAR Simulation Exercise Report	2017	28	Sections 1 – 4, Annexes 1 – 2 (11 pages)
World Health Organization	2nd High Level Technical Meeting on Surveillance of Antimicrobial Resistance for Local and Global Action	2017	30	Background and Meeting proceedings (15 pages)
World Health Organization	Global Antimicrobial Resistance Surveillance System (GLASS). The detection and reporting of colistin resistance	2018	17	Sections 1 – 4 (13 pages)
World Health Organization	Global Antimicrobial Resistance Surveillance System (GLASS). Report of the 2nd meeting of	2018	14	Sections I. – VIII. (11 pages)

Author	Name	Publication Year	Length of the document (PDF pages)	Parts / pages coded
	the WHO AMR Surveillance and Quality Assessment Collaborating Centres Network			
World Health Organization	WHO Expert Consultation meeting on Antimicrobial Resistance (AMR) Health Burden Estimation	2018	17	Executive summary and full proceedings (12 pages)
World Health Organization	Global Antimicrobial Resistance Surveillance System (GLASS). Emerging antimicrobial resistance reporting framework	2018	20	Sections 1 – 3 (16 pages)
World Health Organization	Emerging antimicrobial resistance reporting. Guide for emerging AMR event sharing	2018	20	Sections 1 – 3 (16 pages)
World Health Organization	Global Antimicrobial Resistance Surveillance System (GLASS) Molecular methods for antimicrobial resistance (AMR) diagnostics to enhance the Global Antimicrobial Resistance Surveillance System	2019	64	Executive summary, Sections 1 – 10. Annex 2 (25 pages)
World Health Organization	Global Antimicrobial Resistance Surveillance System (GLASS) Early implementation protocol for inclusion of Candida spp.	2019	26	Sections 1 – 3 (20 pages)
World Health Organization	3rd Meeting of the WHO AMR Surveillance and Quality Assessment Collaborating Centres Network – Meeting Report	2019	32	Executive summary and full proceedings (22 pages)

Author	Name	Publication Year	Length of the document (PDF pages)	Parts / pages coded
World Health Organization	GLASS Guidance for national reference laboratories. Global Antimicrobial Resistance and Use Surveillance System (GLASS)	2020	28	Sections 1 – 7 (18 pages)
World Health Organization	GLASS Whole-genome sequencing for surveillance of antimicrobial resistance	2020	72	Sections 1 – 6 (42 pages)
World Health Organization	GLASS method for estimating attributable mortality of antimicrobial resistant bloodstream infections	2020	92	Sections 1 – 7 (28 pages)
World Health Organization	GLASS The detection and reporting of colistin resistance. Second edition. Global Antimicrobial Resistance and Use Surveillance System (GLASS)	2021	24	Sections 1 – 4 (9 pages)
World Health Organization	Enhanced Gonococcal Antimicrobial Surveillance Programme (EGASP): general protocol	2021	48	Not coded (general review)
World Health Organization	WHO integrated global surveillance on ESBL-producing E. coli using a “One Health” approach: implementation and opportunities	2021	76	Not coded (general review)

Author	Name	Publication Year	Length of the document (PDF pages)	Parts / pages coded
World Health Organization	Antimicrobial Resistance. Global Report on Surveillance	2014	256	Sections 1 – 6 (72 pages)
World Health Organization	Global Antimicrobial Resistance Surveillance System (GLASS) Report. Early implementation 2016-2017	2017	164	Sections 1 – 4 (excluding country profiles), Conclusions (51 pages)
World Health Organization	Global Antimicrobial Resistance Surveillance System (GLASS) Report. Early implementation 2017-2018	2018	268	Sections 1 – 6 (excluding country profiles), Conclusions, Annex IV (42 pages)
World Health Organization	Global Antimicrobial Resistance and Use Surveillance System (GLASS) Report. Early implementation 2020	2020	144	Sections 1 – 5 (excluding country profiles), Annex 1, 3 (65 pages)
World Health Organization	Global Antimicrobial Resistance and Use Surveillance System (GLASS) Report. 2021	2021	180	Sections 1 - 5 (excluding country profiles), Annexes 4,5,7 (96 pages)

Appendix 4. Interview guides

Concerning AMR data sharing

Theme	Question(s)
Background information	1) Could you please tell me about the task of this organization [the NCC] and specify your current work tasks concerning antimicrobial resistance (AMR) and AMR surveillance? 2) How familiar are you with the Global Antimicrobial Resistance and Use Surveillance System (GLASS) and its AMR surveillance activities? 3) How do your current work activities relate to the Global Antimicrobial Resistance and Use Surveillance System (GLASS) AMR surveillance activities?
AMR data collection and sharing	1) Could you please specify how AMR surveillance data is shared between the different stakeholders/sites in your national country context? 2) Is AMR surveillance data collected in your country's context shared with other regional/global AMR systems, such as EARS-Net or GLASS? Could you specify how this data is shared?
Rationale and motivation: AMR data sharing	1) What is the main rationale and motivation to collect AMR surveillance data in the national context? 2) What is the main rationale and motivation to share AMR data outside of your national country context, for example, with the GLASS, or other regional AMR surveillance system(s)?
AMR data surveillance standardisation	1) To what extent does your national AMR data surveillance correspond to the methodology of the GLASS? a. Infrastructure: national focal points, approved reference laboratories, surveillance sites? b. Health domains: human (also animal, environmental)? c. Samples (GLASS: blood, urine, stool, cervical and urethral specimens)? d. Pathogens (GLASS: i. blood: *Acinetobacter spp., Escherichia coli, Klebsiella pneumoniae, Salmonella spp., Staphylococcus aureus and Streptococcus*; ii. urine: *E. coli, K. pneumoniae*; iii. stool: *Salmonella spp., Shigella spp.*; iv. cervical and urethral specimens: *Neisseria gonorrhoeae*) 2) Was your national AMR surveillance system adapted and changed to correspond to the broader AMR surveillance system, such as GLASS? a. If yes, how? b. If not, is it planned to be updated further and how?
AMR data sharing and standardisation: challenges	1) In your view, what are the most common challenges in the AMR data sharing with other AMR surveillance systems outside of your national country context, such as GLASS? a. Could you specify why?

Theme	Question(s)
	2) In your opinion, what are the most common challenges in the AMR data standardisation with the systems outside of your national country context? a. Could you specify why?
AMR surveillance systems: future and expectations	1) In your opinion, what type of action should be introduced (or what type of challenges should be tackled) to improve AMR surveillance in your national country context? 2) What type of action should be introduced (or what type of challenges should be tackled) to improve national AMR data sharing and standardisation to correspond to the broader AMR surveillance systems, such as GLASS? 3) What type of outcome/benefit do you expect while sharing national AMR data with broader AMR systems, such as GLASS? a. What type of outcome/benefit do you specifically expect from the GLASS after sharing the national country data?
Remaining questions	1) Are there any other important points that, in your view, were not addressed during this interview and are applicable to this topic?

Concerning AMR surveillance in laboratories

Theme	Question(s)
Background information	1) Could you please tell me about and specify your current work tasks concerning antimicrobial resistance (AMR) and AMR surveillance? 2) How familiar are you with the activities of the Global Antimicrobial Resistance and Use Surveillance System (GLASS) AMR surveillance activities? 3) Are you aware to what extent the GLASS AMR surveillance activities relate to your work?
AMR data testing and standardisation	1) Could you please specify how do you test samples to obtain AMR data? a. Methods? (e.g., antimicrobial susceptibility testing; whole-genomic sequencing; molecular methods, etc) b. Samples (GLASS: blood, urine, stool, cervical and urethral specimens)? c. Pathogens (GLASS: i. blood: Acinetobacter spp., Escherichia coli, Klebsiella pneumoniae, Salmonella spp., Staphylococcus aureus and Streptococcus; ii. urine: E. coli, K. pneumoniae; iii. stool: Salmonella spp., Shigella spp.; iv. cervical and urethral specimens: Neisseria gonorrhoeae) 2) Does your laboratory correspond to the European Committee on Antimicrobial Susceptibility Testing (EUCAST) or the Clinical and Laboratory Standards Institute standards? 3) To what extent do your current testing methods correspond to the GLASS methodology? 4) Were any new methods/scope of testing introduced because of the GLASS methodology?

Theme	Question(s)
AMR data testing and standardisation: challenges	1) In your view, what are the most common challenges in AMR data testing? a. Could you specify why? 2) In your opinion, what are the most common challenges in the AMR testing standardisation, for instance, according to the GLASS methodology? a. Could you specify why?
AMR surveillance systems: future and expectations	1) In your opinion, what type of action should be introduced (or what type of challenges should be tackled) to improve AMR data testing in the national context? 2) In your opinion, what type of action should be introduced (or what type of challenges should be tackled) to improve AMR data testing standardisation according to the methodology outside of your national country context, such as the GLASS?
Remaining questions	1) Are there any other important points that, in your view, were not addressed during this interview and are applicable to this topic?

Concerning the AMR surveillance sites

Theme	Question(s)
Background information	1) Could you please tell me about and specify your current work tasks concerning antimicrobial resistance (AMR) and AMR surveillance? 2) How familiar are you with the Global Antimicrobial Resistance and Use Surveillance System (GLASS)? 3) How do your current work activities relate to the Global Antimicrobial Resistance and Use Surveillance System (GLASS) AMR surveillance activities?
AMR data collection	1) Could you please specify how AMR data is collected on your surveillance site? a. Which groups of patients do you collect samples from? How do you decide this? 2) Could you tell me how you further share your collected AMR data (i.e. samples) 3) What type of information do you receive back after sharing your collected AMR samples?
AMR data collection and standardisation	1) To what extent do your national AMR data collection endeavours correspond to the methodology of the GLASS? a. Samples (GLASS: blood, urine, stool, cervical and urethral specimens)? b. Pathogens (GLASS: i. blood: *Acinetobacter spp., Escherichia coli, Klebsiella pneumoniae, Salmonella spp., Staphylococcus aureus and Streptococcus*; ii. urine: *E. coli, K. pneumoniae*; iii. stool: *Salmonella spp., Shigella spp.*; iv. cervical and urethral specimens: *Neisseria gonorrhoeae*) 2) Was your AMR data collection adapted to correspond to the broader AMR surveillance system, such as GLASS? a. If yes, how?

Theme	Question(s)
	b. If not, is it planned to be updated further and how?
Rationale and motivation: AMR data collection	1) What is your main rationale and motivation to collect AMR data in your surveillance site? 2) What is the main rationale and motivation to collect AMR data for broader AMR surveillance systems, for example, GLASS, or other regional AMR surveillance system(s)?
AMR data collection and standardisation: challenges	1) In your view, what are the most common challenges in the AMR data collection in your national country context? Could you specify why? 2) In your opinion, what are the most common challenges in the AMR data collection standardisation corresponding to the broader AMR surveillance systems, such as GLASS? Could you specify why?
AMR surveillance systems: future and expectations	1) In your opinion, what type of action should be introduced (or what type of challenges should be tackled) to improve national AMR data collection? 2) What type of action should be introduced (or what type of challenges should be tackled) to improve AMR data collection standardisation corresponding to the broader AMR surveillance systems, such as GLASS? 3) What type of outcome/benefit do you expect while collecting national AMR data for broader AMR systems, such as GLASS? a. What type of outcome/benefit do you specifically expect from the GLASS after national AMR data is shared?
Remaining questions	1) Are there any other important points that, in your view, were not addressed during this interview and are applicable to this topic?

Appendix 5. Interviewees profiles

Interviewee pseudonymization	Expertise	Expertise in AMR	Activities in higher-income (HICs) and lower-to-middle-income (LMICs) countries regarding AMR
Interviewee I	Medical field, epidemiology	Research for AMR surveillance interventions, designing (alternative) interventions for AMR surveillance	Active in both, HICs and LMICs in Europe, Asia, Africa
Interviewee II	Epidemiology, Microbiology	Public health analysis in AMR field, project management in AMR field, including surveillance	Active in HICs in Europe
Interviewee III	Medical field, epidemiology	Clinical research in AMR field, management of a laboratory where AMR is being tested	Active in both, HICs and LMICs in Europe and Asia
Interviewee IV	Epidemiology, health burden calculations	Health burden calculations of AMR	Active in HICs in Europe