Fluid onto-epistemology of human existence and antimicrobial resistance management: understanding and tackling the problem

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Abstract

Antimicrobial resistance (AMR) is usually framed as a technical problem of drug-resistant pathogens, yet for those living with it, AMR is an everyday condition of uncertainty that reshapes what it means to remain alive, treatable, and connected to health systems. This article develops a fluid onto-epistemology of human existence in the presence of AMR, asking how existence, risk and knowledge are co-produced across Thailand's AMR landscape. First, it traces how AMR emerges from ordinary practices and infrastructures – from prescribing, dispensing and surveillance to water, sanitation and food systems – to conceptualise AMR as a slow-onset, super-wicked disaster nested within human lives rather than external to human existence. Second, it examines how human lives are valued, protected or left at risk within Thailand's evolving AMR governance, including tensions between national indicators, everyday therapeutic practices and the position of refugees and migrants at the margins of entitlement. Third, it proposes a communicative-ecology lens for mapping how knowledge of AMR moves between actors, institutions and environments, and how these flows shape possibilities for anticipation, care and accountability. The resulting framework is designed to be transferable and empirically usable: it can be populated with quantitative and qualitative data, scaled between national profiles and local settings, and adapted as stakeholder configurations change. *In the Thai context, this means reading AMR as part of the country's disaster risk profile, especially in refugee- and migrant-affected settings where surveillance is challenging.* Future research on AMR in Thailand – including along the Thai-Myanmar border and in refugee- and

migrant-affected settings will collect and interpret data through this framework in order to better align everyday experiences of risk with policy, surveillance and intervention.

Keywords: antimicrobial resistance (AMR); slow-onset disaster; communicative ecology; global health governance; fluid onto-epistemology

1. Antimicrobial resistance as a complex problem in healthcare and beyond

Antimicrobial resistance (AMR) is a global health emergency that has been causing more deaths than HIV/AIDS and malaria in recent years (World Economic Forum, 2022). The pressing nature of AMR as a public health problem requiring urgent multisectoral action stems, among other things, from its direct and indirect links to the achievement of the Sustainable Development Goals, particularly SDG 3 (WHO, 2021). The problem of AMR is seen as an ever-increasing threat to public health worldwide (Hu et al., 2020). Global burden estimates indicate that bacterial AMR contributed substantially to mortality, with 1.27 million deaths directly attributable and 4.95 million deaths associated with resistance in 2019 (Murray et al., 2022). More recent analyses suggest that, in 2021, AMR was associated with 4.71 million deaths worldwide, including 1.14 million deaths directly attributable to resistant infections (GBD 2021 Antimicrobial Resistance Collaborators, 2024). Modelling data for Thailand indicate a considerable mortality burden from antimicrobial resistance, with an estimated 10,800 deaths directly attributable to AMR and a further 43,900 deaths associated with resistant infections in 2019 (Institute for Health Metrics and Evaluation, 2022). Evidence from hospital cohorts highlights the severity of resistant infections. In southern Thailand, patients with carbapenem-resistant *Pseudomonas aeruginosa* experienced a 30-day mortality rate of 30.5% (Chotimakorn et al., 2025). Resistant infections also impose a significant economic burden in Thailand. Estimates suggest that in-hospital antimicrobial-resistant infections accounted for costs of approximately THB 66.4 billion (USD 2.1 billion) over a five-year period, with productivity losses from preventable deaths comprising more than 80% of this total (Kongnakorn et al., 2023). Various reasons have been listed for the increasing development of AMR around the globe and deaths from the AMR-related diseases/infections. One factor contributing to the growing AMR burden is the long-term slowdown in the development of new antibiotics and antimicrobial agents. This pattern is illustrated by the integrated analysis presented by Dattani et al. (2024) and summarised in Figure 1. Figure 1 illustrates that the majority of antibiotics and antimicrobial agents currently used in human medicine were discovered, developed and commercialised during the 20th century. At the same time, Figure 1 shows a decline in the number of antibiotics and antimicrobial agents introduced into clinical practice since the early 2000s.

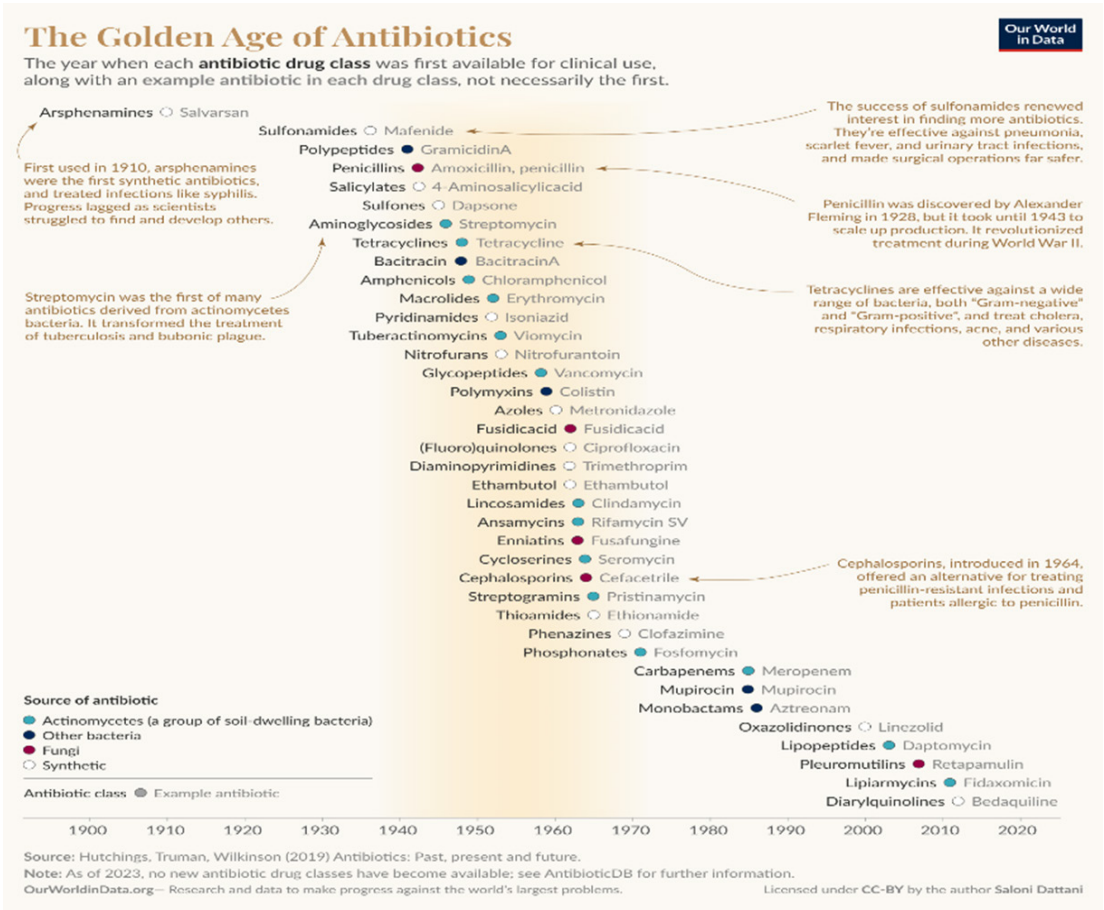

Figure 1. Timeline illustrating the discovery and introduction of antibiotics and antimicrobial agents across the 20th and 21st centuries, based on data reported by Dattani et al. (2024). The figure is reproduced under the CC BY licence.

Building on the slowdown in new antimicrobial classes illustrated in Figure 1, recently, suggestions have been reported in literature that some novel compounds could be used to develop new antimicrobial medicines. These compounds have included fungal-derived terpenoids which could be used to treat infections where the causative agents of disease are pathogens belonging to the ESKAPEE+ group (Ojo et al., 2025). Another potential group of new active antimicrobial therapeutic agents has been the pyrroloiminoquinone (PIQ) family of compounds (Kalinski et al., 2022). The problem is that these and other drug candidate groups are still in various stages of development and are not yet available for routine patient care. As a result, neither of these drug candidates nor their prospective clinical use can therefore have any significant impact on the management of AMR at present or in the near future. Although Figure 1 depicts

antibacterial agents, similar concerns apply to other antimicrobial classes essential to modern care, including antivirals, antifungals and antiparasitic agents.

In this article, antimicrobial resistance (AMR) is used primarily to denote resistance to antibacterial agents in human health, including anti-tuberculosis medicines. This reflects the focus of Thailand's current surveillance systems and national AMR plans, which are most developed for bacterial pathogens (Maguire and Tandlich, 2026). Resistance to other classes of antimicrobials, antivirals, antifungals and antiparasitics is recognised as part of the broader AMR problem but will be considered only secondary in this paper.

A second factor contributing to increasing AMR-linked mortality is the burden of infections caused by ESKAPEE+ pathogens (Figure 2). These include *Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, Enterobacter spp*., and *Escherichia coli* (Miller & Arias, 2024). Pathogen-specific AMR impact is heterogeneous: the AMR-attributable share of deaths among all deaths associated with a given pathogen is < 10% for *Enterobacter spp., S. aureus* and *E. faecium*, with similarly modest proportions for *Mycobacterium tuberculosis* (a major global threat but not part of ESKAPEE+). By contrast, approximately 35% of deaths linked *to A. baumannii* are attributable to AMR, highlighting the particular severity of resistance in this species. Thus, while there is still scope to act, clinical consequences of AMR are already substantial and intensifying for certain high-risk pathogens. Beyond bacteria, resistance in viral, fungal and parasitic pathogens also contributes meaningfully to global mortality. For influenza, resistance to oseltamivir and other neuraminidase inhibitors is reported in seasonal and pandemic strains against a background of hundreds of thousands of influenza-associated deaths each year (WHO, 2023a; CDC, 2024). For fungi, azole-resistant *Aspergillus fumigatus* and multidrug-resistant *Candida auris* continue to spread; recent series report crude mortality for *C. auris candidemia* of approximately 30 to 60% (CDC, 2024; GAFFI, 2023). In malaria, there have been between 568 000 and 619 000 deaths were recorded annually between 2019 and 2021, and the spread of partial artemisinin resistance in *P. falciparum* raises concern about treatment failures and excess mortality (WHO, 2023b).

The third factor that has contributed significantly to the development of AMR as a public health threat is related to the prescribing practices of antimicrobial agent regimens. As an example, Ahmed et al. (2025) showed through a scoping review that the prescribing guidelines are not always followed by healthcare practitioners in South Africa when it comes to the antimicrobial therapeutic agents. Similar findings have been reported in Thailand, where national AMR reports and hospital audits indicate substantial over-prescription of antibiotics for largely self-limiting conditions, and frequent deviation from standard treatment guidelines (Sumpradit et al., 2021; Anugulruengkitt et al., 2023; Ministry of Public Health & Ministry of Agriculture and Cooperatives, 2017). A fourth factor in AMR development is unfinished regimens and sharing of antimicrobial medicines

among patients and their communities (Sharma et al., 2025). These patterns of unfinished treatment, self-medication and sharing of medicines at household and community level have also been observed in Thai studies (Chanvatik et al., 2019; Pumtong et al., 2020). Further challenges in the management of antimicrobial medicines in clinical settings can include the prescription of overlapping antibiotics in a single patient regimen, i.e. more than one group of bacterial agents being used to treat a specific infection (Cassim et al., 2025). Prescription problems have also been shown to be accompanied by limited de-escalation to a narrower spectrum antibiotic after pathogen identification and the antibiogram are known (Cassim et al., 2025). The antimicrobial stewardship (AMS) programmes have been shown as a potential AMR management tool, but they require increased focus on the knowledge of antimicrobial clinical use among formal healthcare workers such as nurses (Rout et al., 2019). Salam et al. (2023) outlined that AMR has been shown to increase as a public health threat by the human use of the antimicrobial therapeutic agents and by the overuse of such agents in animal husbandry. The World Health Organisation (WHO) has more broadly designated combatting AMR as a priority in terms of treating bacterial, viral, fungal and parasitic infections, including specific focus areas such as drug-resistant tuberculosis, HIV, malaria and other high-burden infectious diseases (Bertagnolio et al., 2024; WHO, 2021). This is in line with the comments from the academic and biomedical community about the likely significant rise of bacterial resistance to antimicrobial therapeutic agents by 2050 (Kariuki, 2024). Such data shows that AMR is an important and ever-evolving challenge for public health. Melaku and Assegid (2025) stressed the need for localised solutions and a sociological view of AMR. There is a need for the engagement and understanding of localised parameters of the AMR development, spread and significance from a public health perspective. The complexity of any solutions to AMR is further complicated by the increasing levels and occurrences of detection of non-zero concentrations of antimicrobial agents in various environmental compartments (Kalinski et al., 2024). Because of the complex cause-effect relationships, the threat from AMR is becoming a super-wicked problem (Littmann & Simonsen, 2019; Littmann, Viens, & Silva, 2020; Pokharel et al., 2024). Any solutions must reflect this.

To mitigate this problem, approaches must be developed to optimise and to extend the usability of the available and clinically approved antimicrobial agents in human medicine. Several approaches have been proposed to achieve this such as emergency risk management (Dominey-Howes et al., 2015), phage therapy (Lin et al., 2017) and classification of antibiotics in various categories to optimise their use (Sharma et al., 2020), and in the last five years further strategies have focused on One Health–based multi-sectoral action, strengthened infection prevention and control and vaccination programmes, rapid diagnostic tools and data-driven surveillance, and the development of new or repurposed antimicrobial agents (Velazquez-Meza et al., 2022; Quadripartite, 2022-2026). Another approach has been to strengthen and widen the use of AMS in public healthcare

systems (Shrestha et al., 2023). In the Thai context, AMS implementation has been embedded within the National Strategic Plan on AM and supported through hospital AMS teams, national guidelines and multi-stakeholder collaborations, including public engagement projects on antimicrobial use and resistance (Sumpradit et al., 2021; Poomchaichote et al., 2024). Taken together, these initiatives provide a potential pathway for addressing AMR as a public health threat across global and locally situated contexts in Thailand.

Taken together, this evidence indicates that preventing AMR and understanding its causative pathways require engagement across multiple disciplines and stakeholder groups. Multi-stakeholder approaches need to bring together formal healthcare workers (e.g. medical doctors, nurses and pharmacists), health system managers and policy-makers, with patients, families and patient advocates. The complexity of the AMR challenge tends to erode conventional boundaries between those who make biomedical and therapeutic decisions and those who are usually positioned as passive recipients of care. Deliberate dialogue and engagement across these groups are therefore essential, as illustrated by Mahrous' (2013) work in Saudi Arabia, which used structured stakeholder engagement to inform healthcare services. Similar collaborative approaches have been used in South Africa to co-create health promotion materials on AMR, involving both formal healthcare workers and community healthcare workers (lay workers with limited formal training) to situate AMR messaging within local conditions (Sharma et al., 2025). Within Thailand's National Strategic Plan on AMR (2017–2021), public knowledge and awareness of appropriate antimicrobial use are formalised as a core strategic goal, including a target of a 20% increase in public knowledge and awareness by 2021, supported by national surveys and programme evaluations (Ministry of Public Health & Ministry of Agriculture and Cooperatives, 2017; Chanvatik et al., 2019; Sumpradit et al., 2021). Comparable participatory initiatives have been developed and implemented in Thailand's public engagement projects on antimicrobial use and resistance, most notably the "AMR Dialogues" and subsequent public-engagement activities using the Responsive Dialogues framework with adult Thai communities to co-create stakeholder maps, engagement strategies and locally relevant AMR solutions (Poomchaichote et al., 2022; Poomchaichote et al., 2024). Taken together, these examples underscore that AMR prevention must be understood as a communicative and relational endeavour rather than a purely technical intervention.

The need to communicate with and to accommodate all stakeholders is rooted in the ethical imperative to hear all voices when protecting public health and tackling AMR; in particular, it is necessary to capture the bioethical dimensions and uncertainties associated with AMR as a slow-emerging disaster (Viens and Littmann, 2015). Knowledge management is an important element of this endeavour, and it has been studied in healthcare organisations such as pharmacy retail chains (Dongo et al., 2025). Communication channels function as key platforms for knowledge sharing, and digital technologies such

as WhatsApp groups provide everyday infrastructures through which staff exchange information, coordinate practice and sustain organisational learning (Dongo et al., 2025). In this context, two broad types of knowledge are typically distinguished, namely tacit and explicit knowledge. Tacit knowledge is the hidden and personalised knowledge that an individual, such as a healthcare practitioner, gains through experience, while explicit knowledge is more formalised and generalised knowledge about the management of diseases and the provision of healthcare or patient care (Attard et al., 2022). These distinctions are central to understanding how knowledge about AMR circulates within and between organisations.

Building on these distinctions between tacit and explicit knowledge, Adesina et al. (2019) described the SECI model of knowledge management. This model conceptualises knowledge management through four interrelated processes. The first is socialisation, in which tacit-to-tacit knowledge transfer takes place as individuals share experiences and practices (Adesina et al., 2019). The second process is externalisation, where tacit knowledge is articulated into explicit forms that can be communicated and exchanged, such as guidelines, protocols or written procedures (Dongo et al., 2025). The third process, combination, occurs when explicit knowledge is reorganised, synthesised and transferred from one knowledge holder to another as explicit knowledge (Adesina et al., 2019). Finally, in the internalisation process, the recipient of the explicit knowledge incorporates it into their own practice, thereby turning the new knowledge back into tacit knowledge (Dongo et al., 2025). Practical psychometric instruments have been developed to track and assess the extent of the SECI model implementation in organisations (Farnese et al., 2019). In this paper, the SECI framework is used to conceptualise how AMR-related knowledge moves between clinical practice, organisational routines and wider surveillance structures. In order for knowledge about AMR to be shared effectively, these knowledge-conversion processes need to be embedded within organisational contexts at institutional, national and global levels, where relevant data are systematically collected and exchanged through surveillance and reporting systems. At the global level, many countries track resistance and antimicrobial dispensing/prescribing data and report these to WHO, thereby making them available to the wider international community. This surveillance and reporting systems constitute a large-scale infrastructure for the production, combination and dissemination of explicit AMR knowledge that can subsequently be internalised by national and local health systems.

In Thailand, these global and organisational knowledge processes are realised through national surveillance and stewardship systems. Within Thailand's AMR response, sharing surveillance information is central to knowledge management, particularly for the circulation of explicit quantitative data on antimicrobial use and resistance patterns across facilities and regions (WHO, 2023c). Hospital-based surveillance systems,

such as Thailand's National Antimicrobial Resistance Surveillance Center (NARST) network, generate laboratory data on resistant organisms, while national monitoring of antimicrobial consumption provides complementary information on prescribing and dispensing trends (World Health Organization, Regional Office for South-East Asia, 2019). Together, all these sources of explicit knowledge form the basis for clinical and policy decisions, including the selection of empirical treatment, the design of antimicrobial stewardship (AMS) interventions, and the allocation of resources to high-burden settings (WHO, 2023c). At the level of primary care and district hospitals, clinicians and pharmacists interpret these high-level resistances and use profiles in relation to the conditions they encounter daily—prevalent infections, co-morbidities, supply constraints, and local treatment practices. In doing so, they combine explicit surveillance data with tacit knowledge about their patient populations and service environments to construct an AMR profile for their own catchment areas. This synthesis goes a long way toward guiding rational antibiotic use, but it remains incomplete because it is largely confined to formal health-system data and professional perspectives.

The current article is part of series of article on the nature of AMR as a public health and disaster risk in relation to refugees and migrant communities. The accompanying paper provides an overview of the public health system in Thailand and the related refugee/migrant considerations (Maguire and Tandlich, 2026). This article here will be a review essay which will focus on the theoretical grounding of the AMR and the role of communication in its tackling. Sections of the essay will first continue with analysis of the bioethical challenges of AMR,. Next, foundations for the development of a fluid onto-epistemology will be conceptualized. The conceptualization will lead to a framework for the description and potential analysis existence realm and knowledge about its impact on human lives will be done to conceptualize the fluid and super-wicked of AMR. The following section of the paper will deepen and further develops the actual framework for AMR. AMR is also defined and conceptualised as a source of fluid risk from a disaster risk and public health points of view. Fifth section of the current review essay will focus on the analysis of the open and close aspects of the Thailand governance systems ans how the fluid nature of AMR-related risks can be viewed or has been viewed by it. Sixth section will deal with the fluid nature and impacts AMR risks on the refugees and migrant populations in Thailand. Special role of communicative ecology as a way to provide voices of all stakeholders in AMR will be presented and analyzed from a theoretical point of way...with links to fluid onto-epistemology and refugee/migrant health in Thailand. Final section of paper provides synthesis of the AMR as a slow-onset and super-wicked disaster and how the fluid onto-epistemology can be applied to interpret it in order to develop public health strategies to tackle AMR.

2. AMR as a bioethical and uncertainty challenge

If the previous section framed AMR as a complex epidemiological and systems problem, this section turns to its bioethical and uncertainty dimensions. Overuse and overprescribing of antimicrobial agents are problems contributing to the AMR spread and development. Use of these therapeutic agents in animal husbandry, even though declining substantially in recent years, also contributes to AMR development. However, there are broader bioethical considerations which require attention to achieve just AMR management in global and localised contexts. Pokharel et al. (2024) performed bioethical analysis of the AMR and raised four tensions, or bioethical dilemmas that are highly relevant to the future development of the public health impacts of AMR. Basically speaking, there are discrepancies between the interest of various stakeholders when it comes to AMR. There are tensions between increasing the use of antimicrobials to allow patients in low- and middle-income countries (LMICs), who are most at risk from infectious diseases and who need an increased access to those medicines, and the need to tackle AMR as a global public health problem.

The tension in essence is between allowing increased access to antimicrobial treatment, allowing for the undoing of some historical biomedical and public health injustices between the Global North and Global South. However, this can also cause increased spread of AMR with increased use of and access to antimicrobial therapeutic agents. A tension like this has thus a justice and access dimension, as well as a prevention and mitigation one (Pokharel et al., 2024). The access and justice considerations of increased access need to be balanced against the excess use of antimicrobial agents and potential spread/development of AMR in order to allow optimum access to healthcare for all of humanity and to also protect all of humanity from overuse of antimicrobial medicines. Figures 2 and 3 highlight the uneven global distribution of national systems for AMR surveillance and reporting, with many low- and middle-income settings lacking comprehensive infrastructures to track resistance and antimicrobial use. Another bioethical tension originates from the common lack of laboratory facilities for AMR detection in LMICs and the resulting need for the prescribing of antimicrobial treatment based on a medical doctor's judgement only. This reliance on empirical treatment can in turn contribute to wider development of AMR and related public health challenges in LMICs, where antibiotics are often needed more than in the Global North (Pokharel et al., 2024).

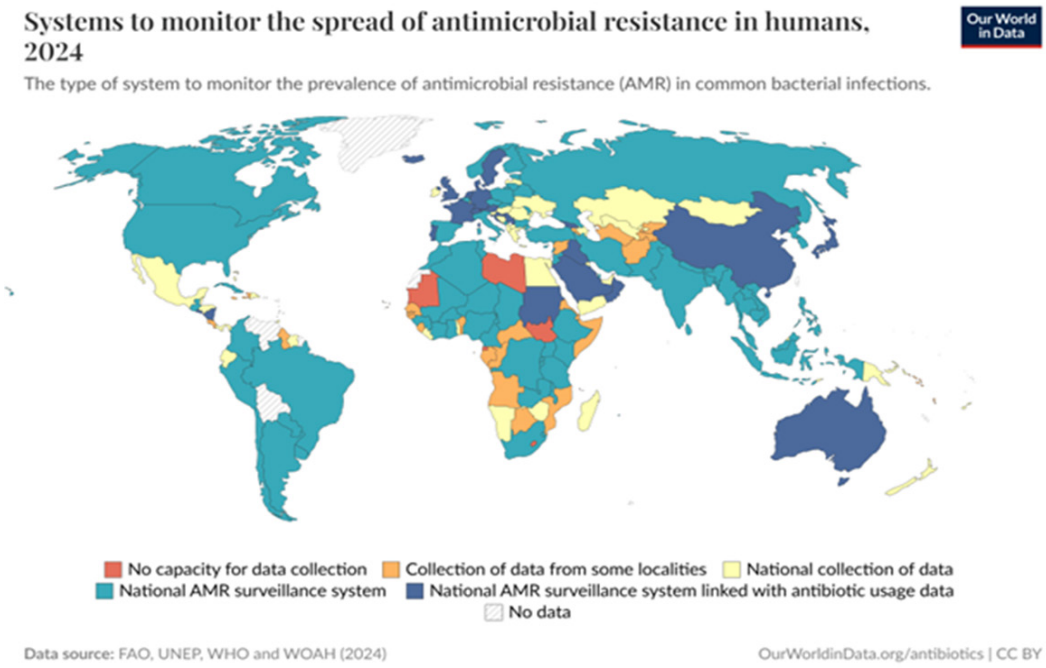

Figure 2. Global distribution of national systems for monitoring antimicrobial resistance in humans in 2024. Data are sourced from Our World in Data (Ortiz-Ospina & Roser, 2016) and reproduced under the CC BY licence (accessed 23 January 2026).

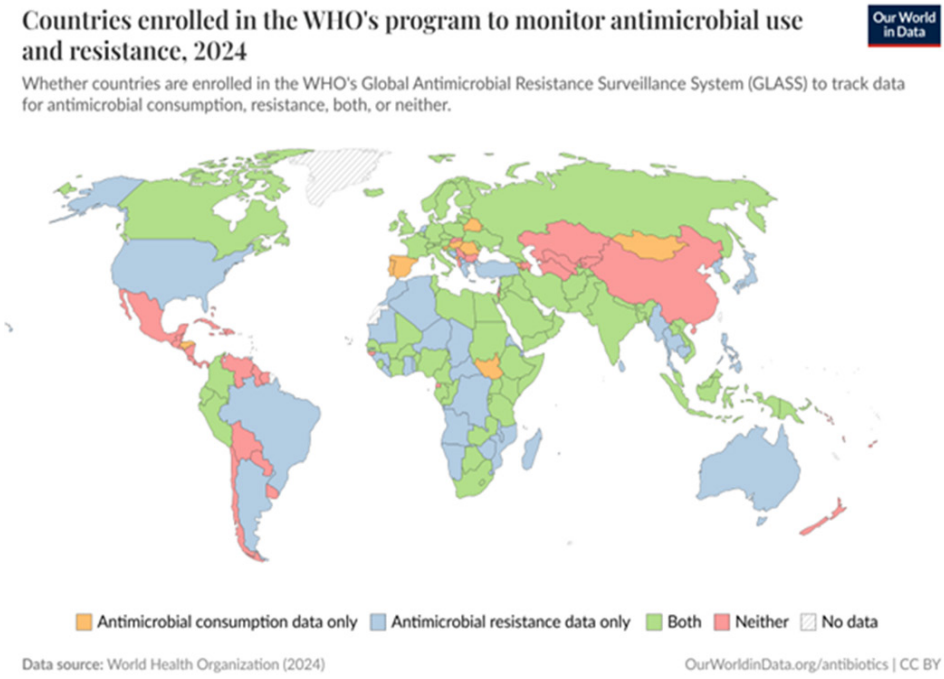

Figure 3. Countries participating in WHO GLASS surveillance for antimicrobial consumption and resistance in 2024. Data are derived from Our World in Data and reproduced under the CC BY licence (accessed 23 January 2026).

These bioethical considerations, along with injustices which occurred in relation to the access to COVID-19 vaccines (Zbiri and Boukhalfa, 2023), also point to the need to undo the historical imbalances that have existed in relation to access to biomedical therapies. However, undoing injustices without strict control of antimicrobial agent use can create a negative feedback loop of negative impact of AMR on human public health. Such feedback loops can also contribute to the increase in the uncertainty related to the development of AMR as a public health risk and as a super-wicked problem globally and locally. Finding the right balance and developing an ontological understanding about these challenges will be important in battling AMR.

Further on the bioethical front, AMR predates the development and therapeutic use of antimicrobial medicines (Santiago-Rodriguez et al., 2015). Lixandru and Amfim (2023) have listed factors which complicate the AMR picture even more. One of those factors is the fact that AMR, and the mobile and static antibiotic resistance genetic elements that underpin it, have been present in the microbial kingdom since before the discovery and therapeutic uses of antimicrobial agents by humanity (Baron et al., 2018; Davies & Davies, 2010). These genes were expressed at low levels and resulted in no apparent impacts on humanity or the wider socio-ecological

system (Baron et al., 2018). Discovery of antibiotics and their use in treatment of infectious disease is widely acknowledged to have reduced infectious disease mortality and extended human life expectancy, but it also triggered a significant increase in resistance occurrence and the respective gene expression, leading to the AMR problem we have today (Baron et al., 2018). As a result, any strategies aimed at tackling AMR must consider the inherent presence of AMR in socio-ecological systems and the uncertainty this introduces into the management of AMR. At the same time, there are increased chances of AMR genetic element transmission in urban and highly developed environments, where AMR-holding strains of bacteria circulate in human populations and where the risk from AMR-related infections is the highest (Lixandru & Amfim, 2023). Populations worldwide are becoming increasingly urban in nature (Ritchie et al., 2024) and so this type of urban AMR transmission is becoming more relevant from a public health point of view. Increasing human reach to areas which had previously been inaccessible further increases the potential contact of humans with novel vectors and genetic elements of infectious diseases, which would require antimicrobial agents to treat. Uncertainty comes from the substantial lack of data on the transfer of genetic elements of AMR between the environment and human/animal reservoirs (Lixandru & Amfim, 2023; Berendonk et al., 2015).

The picture is also further complicated by the need for One Health considerations, as Ramey and Ahlstrom (2020) showed that many synanthropic and peridomestic species of animals contain drug-resistant strains of *Escherichia coli* and other bacteria. These strains can be exchanged with humans and domesticated animals, making AMR management even more complex. As a result, the AMR impact on humanity is a clear example of a super-wicked problem, with highly complex cause-and-effect relationships. Humanity has some time to tackle AMR, but the time for action is very short. Solutions to AMR, as a slowly-evolving disaster, are going to be complicated. Besides the super-wicked nature of the problem, there is inherent uncertainty, an inherent property of AMR as part of the socio-ecological systems in which humans live. In addition, there is a social and bioethical dimension to this complexity, rooted in the historical injustices between the Global North, where overuse of antimicrobial agents has largely contributed to the current AMR super-wicked problem, and the Global South, where access to antimicrobial therapeutic agents is often a matter of survival.

The information in this section shows that AMR development, management and mitigation are highly complex globally and in specific local settings. Effective AMR management must be based on strategies which are effective and which buy enough time until new antimicrobial agents become available and approved for use in human medicine. Developing such strategies requires healthcare systems and their stakeholders to have a comprehensive understanding of the AMR development

landscape. This includes understanding of the lived experiences of humans who can suffer from and contribute to the development of AMR, i.e. formal healthcare workers, community-based health workers and patients. Any successful strategies must also take into account the conduct of formal healthcare professionals and the public health policy landscape. Ongoing monitoring and updating of the knowledge about AMR, i.e. effective SECI management of tacit and explicit knowledge of all relevant role players, are crucial to capture the fluidity of AMR development. Role players, as actor in the AMR space who can make decisions and take actions to find solutions to tackling AMR, are all stakeholders and voices in the socio-ecological systems and the public healthcare system of countries like Thailand. Because AMR is a super-wicked and emergent problem, the content of this knowledge cannot be static: it has to be continually revised in light of new epidemiological data, changing treatment practices and shifting socio-ecological conditions, such as those described in recent global and Thai AMR analyses in the preceding section.

There is also the need to consider the ontological nature of human existence in the omnipresence of AMR-causing genetic elements in the human living space. Humans interact with AMR-causing transmission signals on a daily basis and carry these in themselves through inappropriate use of antimicrobial agents and through functioning as hosts to drug-resistant strains of causative agents of disease. Humans need to understand those ontological implications in combatting and tackling AMR. There is also a need to develop and to gain an epistemological understanding of the fluid nature of AMR development and to continuously update it. AMR management must be based on this updated information, i.e. living with AMR and gaining knowledge about it in the general and highly personalised domain is required. This forms an onto-epistemology which is a combination of lived experiences, and personal and scientific knowledge about AMR. That combination can be an effective basis for the development of strategies to mitigate the public health impacts of and risks from AMR. Such a fluid onto-epistemological approach must take into account the super-wicked nature of AMR, with its inherent fluidity and uncertainty, and the corresponding need for continuously updated, situated knowledge about how AMR is unfolding in particular places and populations. The following section therefore develops this fluid onto-epistemological framework further and outlines how it will be used to analyse AMR-related knowledge and practice in the Thai context.

3. Nature of the fluid onto-epistemology and aims of the current study

This section translates the preceding ethical and uncertainty challenges into a clear set of aims for the article. Against the bioethical and uncertainty challenges outlined above, this article has three interrelated aims: first, to conceptualise AMR as a fluid, super-wicked risk embedded in socio-ecological systems; second, to develop

a 'fluid onto-epistemology' that links lived experience, tacit and explicit knowledge, and formal surveillance; and third, to situate this framework within Thailand's AMR response, with particular attention to refugee- and migrant-affected settings. AMR development is therefore treated here as an expression of fluid onto-epistemology in relation to human health and to the socio-ecological systems that humans live in. The authors adopt a risk-based view of AMR, where AMR can be understood as both a hazard (a potential source of threat to human wellbeing) and a risk, when a specific causative agent of infectious disease becomes resistant to standard and available therapies, and this poses a risk to actual human populations. Humans move, develop and change over time, which leads to health hazard and risk from AMR being fluid in time and across the anthropic space, the space that humans inhabit and can be mobile in/throughout. This fluidity is related to the nature of the existence of humans in the presence of AMR as a fact of life and a potential threat to the quality of that life. In Thailand, this risk-based view is especially relevant in border provinces and urban informal settlements, where mobile populations, empirical antibiotic use and uneven surveillance create shifting patterns of exposure to drug-resistant infections (Chanvatik et al., 2019; Sumpradit et al., 2021).

The framework developed in this article is intended to be transferable across different forms of antimicrobial resistance. For the purposes of the present analysis, this empirical scope remains focused on resistance to antibacterial agents in human health, including anti-tuberculosis medicines, in line with Thailand's current surveillance and policy focus. The developed framework is robust and could extend the same fluid onto-epistemology to antiviral, antifungal and antiparasitic resistance as relevant data and stakeholder configurations become available.

It is also linked to the cohabitation of humans with microorganisms that are useful and that are exploited by humans for various needs in life. These include the human gut microbiome, which is important for the maintenance of human health (Khalil et al., 2024). There is the use of microbial strains to actually produce antimicrobial medicines (Haque et al., 2024), and therapeutic agents where genetic manipulation is often part of the process optimisation (Sadanov et al., 2025). Long before the advent of antimicrobial medicines and therapeutic agents, the human gut microbiome was suggested to have exchanged AMR genetic elements with the environment (D'Costa et al., 2006). Baron et al. (2018) showed through review of literature data that the human microbiome is fluid in time, shaped by diet, travel, healthcare contact and other life events. For example, Leangapichart et al. (2016) documented the temporary acquisition of extended-spectrum *β*-lactamase-producing *Escherichia coli* and *Klebsiella pneumoniae* in the gut microbiota of Hajj pilgrims, illustrating how short-term movement and contact with new microbial environments can rapidly alter human carriage of resistant organisms. These examples underscore that humans live

with, depend on and continually exchange genetic material with microorganisms, including AMR determinants.

Humans are also a contributing source of the extent to which AMR as a hazard or health risk, and this will impact their health. The previously discussed fluidity and uncertainty of AMR from the management and public health point of view have an impact on the strategies that are implemented to manage it. In order to achieve effective AMR management, engagement with all the stakeholders and collection of all the relevant data on the AMR landscape are required. Stakeholders to engage with include medical and healthcare professionals, patients and the wider society, as well as community-based and migrant health workers in settings such as Thailand's border provinces and refugee-hosting areas (Maguire and Tandlich, 2026). Bioethical and biomedical considerations have to be understood and balanced on the boundary between the interests and professional mandates of these stakeholders. Ongoing monitoring and updating of AMR-related knowledge, using SECI-type conversion between tacit and explicit knowledge across these groups, is necessary to track how AMR risks are perceived, communicated and acted upon in practice. To this effect, the auhtors will seek to develop a fluid onto-epistemology of AMR that integrates these lived, clinical and policy perspectives, and the subsequent theoretical framework section elaborates the communicative ecology and knowledge-management concepts that will be used to analyse AMR-related practice in the Thai context.

4. Theoretical framework for fluid risk

Having outlined the empirical, ethical and ontological contours of AMR, this section sets out the theoretical tools that will be used to analyse AMR as a form of fluid risk. Beck's notion of the "risk society" provides a first pillar of the theoretical framework for this article, highlighting how late-modern risks such as AMR are manufactured, unevenly distributed and reflexively recognised within societies (Jong, 2022). Ethical reasoning in the form of metaphors offers a second pillar: metaphors are treated here not as rhetorical decoration but as analytical devices that make the complexity and fluidity of AMR intelligible in everyday terms. Building on Peirce's philosophy of abduction, the article employs ampliative reasoning to develop and refine such metaphors in response to emerging empirical knowledge about AMR (Fann, 2020). Intersectionality, as articulated by Collins and Bilge (2020), is used to attend to how social position, migration status and health-system location shape which AMR risks and responsibilities become visible or invisible, particularly in Thailand's refugee- and migrant-affected settings. Taken together, these elements constitute a theoretical lens for analysing how AMR is problematised, communicated and managed as a fluid, super-wicked risk.

Building on the pillars outlined above, this subsection develops one strand of the article's fluid onto-epistemology by focusing on how human beings *are* in the world

and how they *know* and navigate risk under conditions of increasing complexity. Onto-epistemology here signals the inseparability of ontology… the changing realities of everyday life, education and health and epistemology - the ways in which these realities are rendered intelligible through experience, metaphors and formal knowledge systems. To make this linkage analytically tractable, the subsection introduces a set of probabilistic metaphors, developed in previous philosophical work on education and disaster risk, that conceptualise life as governed by different 'dice' of probability. Although the initial examples are framed in terms of upbringing and fluid human existence, their purpose in this article is to clarify what is meant by *fluid risk* and to show how different regimes of probability structure both being and knowing. This, in turn, prepares the ground for adapting the dice metaphors to AMR as a slow-onset, super-wicked disaster within Thailand's refugee- and migrant-affected health systems later in this subsection.

To make the idea of fluid ontological reality more tangible, the discussion turns first to education and upbringing as examples of how human beings learn to navigate complexity. Education and training are complex topics and are also among the complex properties of human existence. Delors and UNESCO (1996) describe education and upbringing in terms of four interrelated dimensions

> "learning to know, learning to act, learning to live together, learning to be an authentic personality"

which together point to the breadth of capacities a person is expected to develop over the course of their life. Complexity in these domains has only increased in recent years, due in part to the increased speed of social interactions and to the growing complexity of communication, for example through social media (Iheanetu et al., 2023). Iheanetu and Tandlich (2022) employed a series of metaphors to analyse the effects of the coronavirus pandemic on the human population, showing how such crises reveal the need to think about human life and upbringing in a fast-changing, interconnected world The approach of Iheanetu and Tandlich (2022) shows how to conceptualize the ontological realm of existence and the uncertainty that humans might face when the nature of reality becomes unpredictable and highly fluid. Such conditions exist in relation to human existence in the presence of AMR.

Based on these metaphors, the authors argue for the emergence of a new science of life and existence of *Homo sapiens*, both as an animal species and as a community of individual beings and a universal living organism, as a result the new ontological and epistemic reality inside and outside of the COVID19 space-time**.** *It is therefore necessary to develop a new paradigm for quantitative and qualitative analysis of how people cope with both normal and complex situations. This paradigm should allow for a critical analysis of the dimensions of the ontological reality of human beings, as*

individuals and as a group creature trying to cope with everyday situations in a "normal and complex ontological environment". A new science of living in and understanding of human ontological reality and epistemological existence in that reality must be developed. One of the developmental stages of this science is concerned with how people cope with experiences and with the lifelong status of living in a new ontological reality…how they respond to increasing complexity in 'normal and complex ontological environments'. Experiences, and their interpretation in the mind and body of the human organism, become fluid and non-standard, characterised by non-constant states of the quantities that describe human existence. COVID-19 existence is one example of such fluid ontological space: a situation in which human beings must adapt to previously unknown realities and changes in the environment of their existence. In such conditions, individuals must not only cope with fluidity but also develop an awareness of the degree of fluidity and complexity of their situation. Education in this context plays an important role, equipping people to recognise the state of their existence and the complexity of the situations they have to deal with COVID19, just like AMR, are fluid ontologically and also in terms of the knowledge creation about that fluidity. All humans are impacted by AMR, all have information about the AMR development and impact. All humans are thus epistemologically knowledge holder about the fluidity and uncertainty of the AMR risk. They must educate themselves and each other about this risk and threats from it.

The complexity of ontological reality and the fluidity of the everyday reality of human life can be characterised using the metaphor of dice (dice and die will be used as synonyms in further text of this article as with AMR they represent ontological reality in which humans are faced with threat of AMR due not one but multiple antibiotics) and associated probability distributions. The three-beam scale metaphor of Iheanetu and Tandlich (2022) is replaced here with the dice and the related probability metaphors to develop the onto-epistemology framework for the analysis of AMR. Already in the 1920s, the first category of probability was defined; two more definitions followed in the subsequent decades. These three categories, namely *a priori* probability, statistical probability and other probability. Those categories can be translated into three conceptual dice that represent different modes of ontological certainty and fluidity. First, the three probabilities are defined; they are then used as metaphors to interpret human existence under normal situations and during complex situations, in the fluidity of contemporary human existence.

The dice metaphor provides one way of expressing how predictable and unpredictable elements of everyday life are distributed. Suppose that there are a certain number of possible outcomes for situations in the daily lives of human beings. Suppose further that the situations and the outcomes of these situations can be compared to numbers, such as the outcome of a dice roll. The outcome of this experiment has a finite number

of possible outcomes, that is, the outcome of the dice roll can be any number from 1 to 6. The probability of each number as the outcome of the experiment is 16.67%, or 1/6. The die used in the experiment is called a normal die because it complies with the rules of *a priori* probability. This die adheres to the laws of *a priori* probability and every human being understands this and can understand it in the dimensions of his or her everyday existence. All possible outcomes of how a human being understands the result of a given roll as a metaphor for a certain life situation are equally probable and also understandable for all human beings. This *a priori* die can therefore be understood as a metaphor for normal life and the normal existence of a human being. The numbers on the die represent everyday situations and express the complexity of human existence, which is limited. A person can orient themselves in it; they can interpret the numbers on the die as metaphors for the ontological reality in which a person exists. The fluidity in this ontological existence is limited and the *a priori* die as a metaphor indicates the stability of everyday life. Education and upbringing are, in the ontological reality, *a priori* dice based on predictability and clearly defined rules of the game, the rules of social consensus about education and its content. In relation to AMR, the a priori die would represent an ideal situation where the antibiotics and antimicrobials would be administsred and used therapeutically as rationally as possible. Prevalence of resistant strains, sa causative agents of disease, would only occure asa result of spontaneous mutation on the bacterial genetic material. Clinical significance of such cases would be limited. Healthcare workers would be able to predict the occurrence of AMR with high degree of confidence. The evaluation of risk from AMR would be predictable, and education of the population at risk would be limited to routine health promotion campaigns.

Now we will look at another variant of the ontological reality of human existence; the experiment from the previous paragraph will be repeated, but the dice will not be normal and will not be based on *a priori* probability distribution. The possible outcomes of the roll will be the same, i.e. 1, 2, 3, 4, 5 or 6....situations in human life remain the same, but their manifestation in the ontological reality of everyday life is different from the *a priori* probability. Unlike the previous format of the given experiment, the probability of one of the numbers from 1 to 6 falling on the dice will not be constant. For example, the probability of falling 1 is 25.0%, 2 is 14.2%, 3 is 0.8%. For this die, the probability of the number 4 falling is 7.2%, the number 5 falling is 22.8%, and the number 6 falling is 30.0%. This probability distribution does not exist *a priori*, but it is possible to predict it.

In other words, it is a statistical die that was used in an experiment. If this die and its possible outcomes in experimental throws are used as a metaphor for human existence, then the position of the human individual is more complicated than with the *a priori* probability of everyday existence. At the same time, however, this statistical nature

of human existence will be predictable and it is possible for each person to adapt to differences in probability: differences in how likely it is for a person to encounter given ontological situations from 1 to 6. The probabilities of individual numbers, as outcomes of a statistical die roll, are different, but quantifiable and predictable. A person can adapt to them and can react if a given number appears on the dice; to the situation that is associated with that number. A person has to deal with these situations in everyday life, but he can prepare for them and can react to them with the help of social support and information, education that help a human being understand and adapt to the standard numbers from 1 to 6. On a statistical dice, in a life situation that is metaphorically equivalent to the numbers from 1 to 6, it is possible to prepare for the results of the rolls where these numbers appear. If a given number appears on the dice, then only the human response to 1, 2, 3, 4, 5 or 6 is activated. With an *a priori* die as a metaphor for life, a person can predict how often a given type of situation is likely to occur. In contrast, human existence under the statistical die is characterised by a higher degree of fluidity. Individual situations in an individual's life are different and occur with different probabilities, but this probability can be quantified and human beings can learn to understand it. If this metaphor is now applied to education and training, it can be said that a person will be in a state where it is necessary to constantly adapt to the fluid situation of the standard dice, which defines the ontological reality of human existence. The norms of this reality, despite the fluidity, sooner or later stabilize and remain at constant values of the probability of outcomes from 1 to 6. Therefore, fluidity is part of human existence, but the predictability of this existence of individual situations in ontological reality allows us to achieve a certain degree of stability and the ability to adapt to the occurrence of situations from 1 to 6. The education of the human society or humans as individuals about AMR, in terms of the standard die, would include accepting that the prescribing the use of antibiotics and antimicrobial therapeutic agents is not rational. The laboratory and diagnostic facilities are not always available. However, there is exchange of enough information about the AMR among all the stakeholders that the probabilities of the statistical dice of AMR, can be continuously updated, shared among the healthcare decision-makers and patients. Such common education and sharing of information provides a solid basis for the fluidity of the changing probabilities on the statistical die to be understood in near real time. AMR and the clinical prevalence of the resistant strains will increase above the level from the a priori die, but it will be manageable using the therapeutic agents, clinical treatment protocols and existing resources in a given public healthcare settings. The super-wicked nature of the AMR might manifest, but its impacts on humanity will be limited.

The third die in this metaphor – the 'other' die – represents situations characterised by radical uncertainty and potentially catastrophic outcomes. The third option is an other die: the possibilities on the die are the same from 1 to 6, but the person does not know

whether the die is a priori or a statistical die, or no information is available about the die. It is impossible to predict which number will fall, which number will be the result of an experimental roll. The probability of falling 1 or another number on another die cannot be predicted. Some of the possible outcomes of a roll of another die lead to a penalty for the human being and some do not. More precisely, if a number from 1 to 5 falls on another die, then life continues normally and the person can prepare, adapt to the given value of the other die as the result of the given experiment. However, if 6 falls, the person, who is subjected to the ontological reality of the other die as a metaphor for his existence, experiences a catastrophe (Maguire et al., 2023). A person will encounter a situation in his existence that does not make sense, where nothing can be done to suppress the consequences of this situation and their impact on the human existence of the affected individual. Ontological uncertainty increases and it is impossible to predict how to prepare for a given situation, how to react to it. Iheanetu et al. (2023) derived the principle of the *utilitarian qubit*, i.e. this is a state of human existence when a person as a human being feels pain and joy at the same moment. At the same time, this person cannot recognize to what extent joy or pain dominates; both feelings are simultaneous factors of human existence. Suppression of joy at the expense of pain, or the source of pain as such, can be the source of an incident, crisis, emergency that requires the intervention of crisis management components, or can occur in an irreversible state of catastrophe (Maguire et al., 2023). In situations where a person is subjected to the outcomes of situations like numbers on another die, the fluidity and unpredictability of the ontological reality of human life is at the highest level compared to the *a priori* and the statistical die. It is impossible to predict which life situations a person will have to deal with in the short term of his existence. If these situations occur, he will have to adapt again to the new parameters of the ontological space. Before a human being adapts to a specific situation, the parameters of the ontological space will change again...human existence will be in a state of infinite fluidity. Education and training become problematic and extremely complicated. A person in a state of another existence will need advice and will have to constantly and quickly find out how to gain experience and skills to cope with the possibility and consequences of the number 6 falling on another die, in a specific life situation. If AMR progresses as per the another-dice metaphor, then the impacted human population will exist in an educational mine field about AMR. There will not rational use of antibiotics or antimicrobial therapeutic agents Laboratory facilities for diagnosis of resistant strains, and other resource to tackle AMR, will not be available to the public health system in the given location. The super-wicked nature of AMR and impacts on the said human community will be beyond onto-epistemological comprehension. Number of the AMR-related deaths will be high, and source so infection will be difficult or impossible to identify/diagnose.

Different life situations can develop according to any type of probability. It is important that a person has access to current information and that it is possible to

continuously exchange information with other human beings. Access to and exchange of information can be the difference between whether the dice/die of life behaves as an a priori, standard cube or not. This will be part of human education and will depend on the society in which the person will find themselves. The essence of education and training is the development and acquisition of skills to obtain essential information and the ability to analyse it, so that the person as a human being can determine, become aware of and respond to the situations in which they find themselves. An effective educational process should contribute to the fact that the person can settle into the situations of everyday life, so that the person can recognize whether their life situations unfold according to the distribution of the *a priori*, standard or other dice/die. Much of education and training and the system how these systems are implemented depend on the society and collective in which human beings exist. The phenomenological and philosophical relationship between the individual, the dice/die of their ontological reality, and society and the educational systems of the given collective will be analysed in the following section. The society or human community in question will need to share information and to continuously capacitate, an educate its stakeholders about the latest status of the AMR. Given fluidity of the ontological realm of human existence in the 21st century, there will be an ideal outcomes if the AMR would be tackled under conditions that align with the metaphor of the standard dice/die.

The role of society in the fluidity of existence and in determining the type of ontological dice/die of life, the type of dice/die of life will have a fundamental impact on the state of the ontological reality of a human being. The more the ontological reality resembles another dice/die, the more difficult it will be to predict the nature and fluidity of this reality. This can lead to complex and fluid situations in the lives of human beings. These situations can be named in several ways. Maguire et al. (2023) proposed a theoretical scale from incidents to accidents and crises to disasters. This scale is a phenomenological expression of the degree of fluidity and complexity of the ontological space of the existence of a human being. It is a name and a tool for analysing situations and conditions of human existence during deviations from normality, i.e. during the coronavirus pandemic or during the education and upbringing of humanity in a state of increased fluidity that approaches the ontological reality of another dice/die.

In this article, this probabilistic–ontological framework is adapted to the analysis of AMR as a form of fluid risk. AMR-related events range from infections that are reliably treatable with first-line antibiotics, which resemble outcomes on the *a priori* or statistical dice, to multidrug- or extensively drug-resistant infections that behave more like outcomes on the other die: infrequent but potentially catastrophic, difficult to predict in advance and often poorly captured by existing surveillance

systems. In Thailand's border provinces and urban informal settlements where refugees and migrants live and seek care, empirical antibiotic use is common, health-system capacity is uneven and care pathways are fragmented across public, private, non-governmental and informal providers (as described in the concurrent article by Maguire and Tandlich, 2026). Under such conditions, patients, healthcare workers and community-based providers are particularly exposed to other-die configurations of risk. The dice metaphor is not employed as a literal probabilistic model, but as an analytical device for thinking through how different actors experience, anticipate and respond to AMR under varying configurations of ontological certainty and fluidity. In doing so, it links the philosophical discussion of fluid human existence with the practical realities of AMR management in Thailand, thereby contributing to the fluid onto-epistemology developed in this article.

Within this framework, repeated references to information and education are not incidental, but indicate the mechanisms through which individuals and collectives navigate fluid risk. Information refers both to the availability and structure of signals about risk… for example, data, observations and warnings—while education denotes the socially organised processes through which actors learn to interpret and act on such signals over time. Together, they mediate the relationship between the three dimensions of human existence and the probabilistic regimes of the *a priori*, statistical and other dice: they shape whether people can recognise the kind of ontological space they currently inhabit and what forms of adaptation are thinkable. In the context of AMR, this pairing anticipates the later discussion of surveillance systems, professional training and community-level risk literacy as determinants of how AMR is experienced and governed, particularly in Thailand's refugee- and migrant-affected settings (Maguire and Tandlich, 2026). Refugees and migrants in Thailand will be mobile across regions and borders in South Asia. Mobility and the interactions of the refugees and migrants with the Thailand's public healthcare system. The country of origin, the migration path to Thailand, and the overall health status of the particular refugee or migrant, as well as their groups (such as families), will form the intersectionality of the refugees, migrants and their communities, or communities in which they will access Thailand's healthcare system. Understanding the intersectionality of these mobilities will be critical to determine which dice metaphor will best describe the AMR development and management in the border and migration regions in Thailand. Public healthcare system in Thailand will have to gain the understanding of the mobility and its intersectionality as part of its ongoing communication, information sharing and education of stakeholders.

5. Open and closed socio-biological systems and knowledge flows in Thai AMR governance

Building on the probabilistic metaphors of fluid risk, this section turns to how human societies can be understood as open or closed socio-biological systems, and how this shapes AMR governance in Thailand. The coronavirus pandemic is one among many complex and multidimensional problems that characterise the twenty-first century. In this period, new forms of risk and disruption are continually emerging, and the dimensions of human existence have become increasingly intertwined in a multidimensional ontological and educational reality. The state of existence in the *a priori*, standard and other dice/die, and the broader dimensions of ontological reality, overflow into and influence one another. For the purposes of this article, three analytical dimensions of human existence are distinguished. The first is the physical dimension, which comprises the place of birth, the spaces in which a person lives and moves, and the "GPS coordinates" of the ontological framework of an individual's existence. The second is the cultural–historical dimension: the system of cultural norms and traditions, moral foundations, ethical norms and social principles to which an individual is subject as a member of society, including the historical and linguistic features of that society's ontology. The third dimension is the communicative dimension, namely the exchange of information and communication between individuals in society. Contemporary communication is itself multidimensional, ranging from uploading videos or photographs to social networks, to writing blogs or posts on the internet, to classic forms of face-to-face verbal interaction (Iheanetu et al., 2023). Reactions and exchanges of information help human beings to complete the 'facts of life' and to gain mastery over everyday situations by obtaining information that enables them to recognise whether their ontological reality resembles the *a priori*, standard or other dice/die. These interlinked dimensions shape the education and upbringing of individuals in the complex and fluid ontological space of the twenty-first century and affect all aspects of education as outlined by Delors and UNESCO (1996).

From a philosophical point of view, the first and second dimensions of human existence can be described as deterministic and reductionist. The deterministic nature of these dimensions means that a human being is tied to a particular location, to a particular set of physical objects in their immediate environment. Determinism also binds human existence to membership in a given language group, to which cultural traditions and certain reductionist features of human existence are also tied. By contrast, the third dimension of human existence, especially in the complicated terrain of the twenty-first century, can be considered maximalist, expansionist or anti-reductionist. Human societies can thus be considered as socio-biological collectives. The third dimension contributes to an open and anti-reductionist view of human existence. From an analytical point of view, these three dimensions of human existence can

be considered as both a manifestation and a tool for perceiving the socio-biological collective as an open or closed system. The openness of the socio-biological collective, as a system of human existence, therefore leads or encourages human beings to adopt a more pluralistic approach to the management of the daily operations of human existence. Practically, this means that individuals draw on all available information to identify the ontological reality of their existence. It is also about identifying whether the individual is in an ontological reality according to the *a priori*, standard or other dice/die. Pluralism and an anti-reductionist approach can and should be transformed into the norms of everyday life. They should practically lead to a plurality of voices within society and should be reflected in the language and media of cultural frameworks and paradigms according to which the individual, as part of society, acts. From this analytical perspective, the three dimensions of human existence allow human societies to be divided into two broad types: open and closed. The degree of openness or closure, in turn, shapes how educational systems, health systems and other institutions are organised, accepted, and how they respond to complex risks such as AMR.

If such socio-biological collectives' function as closed systems, then the physical and cultural–historical, deterministic and reductionist dimensions can be considered dominant. The traditions of history and culture, the customs and language norms of information exchange and acquisition in society bind and limit the exchange of ideas between people within the socio-biological collective. This collective can be a nation or an ethnic group that occupies a contiguous territory or physical space that has definite physical features and established customs. The communicative dimension of human existence in a closed system is significantly limited and may even be actively suppressed by the structures of governance of the socio-biological collective.

By contrast, if the socio-biological collective behaves as an open system, then the physical and cultural–historical, deterministic and reductionist dimensions of human existence are in balance with the communicative dimension. A system, nation or ethnic group exchanges information with the outside world, and may even do so proactively through the governing structures of the relevant socio-biological collectives. In this conceptualisation, a closed system would be considered as one with a high degree of internal coherence among its members. This agreement would be manifested through the habits of everyday contact between members of the collective, but also through the actions of a management structure that could impose on the members of the relevant socio-biological collective a unifying agenda that prioritises internal stability over external exchange. The constant nature of ordinary and everyday activities in a closed space should theoretically lead to the definition of the parameters of the ontological space of human existence. Based on this constancy, a human being should normally face only *a priori* situations or situations governed by

the statistical die. Stability should lead to the predictability of everyday life and also the possibility of adapting to a change in the probability of occurrence of outcomes from 1 to 6. The problem arises when the closed system of the socio-biological collective is exposed to unforeseen external intervention and lacks information about the nature of the cube that now governs its ontological reality. Such unprecedented changes in the parameters of the ontological space of human existence increase the complexity and fluidity of that space. In contemporary public health and in relation to refugee/migrant health specifically, including AMR governance, this distinction between open and closed systems is reflected in how states and institutions manage cross-border information, resources and responsibilities when confronted with novel or evolving risks.

In an open socio-biological system, such societal consensus is diminished or rendered fluid due to the constant exchange of information, i.e. the expansion and increased importance of the communicative dimension of human existence. Access to communication platforms and the exchange of information between members of socio-biological collectives and the outside world are inherently anti-reductionist. Through the openness of the socio-biological system, growth and new thought can bring a new dimension to the physical and cultural–historical dimensions of human existence. The "GPS coordinates" of objects and the constants of the deterministic and reductionist dimensions of human existence remain in place, but the users of these objects have the opportunity to develop and expand their horizons with members of another socio-biological collective. In all the situations discussed in this section, it can be stated that they must be communicable and that a social consensus must also be reached about them. In view of this, the communicative dimension should be sufficiently unified so that the community or socio-biological collective has a common language and speech in order to achieve coherence of individual political approaches. Similarly, as Biziková (2023) says, presenting three dimensions of political coherence:

> "1….horizontal dimension, which concerns inconsistencies or gaps in the policies of individual sectors…"

– in our case, this includes linguistics with regard to the use of the official language and the language of national minorities in everyday life and pedagogy supporting education in given language variants in order to ensure a good quality of life for given citizens.

> 2. "vertical dimension and coherence, through which it is possible to harmonize policies and approaches at the national level across administrative institutions."
>
> 3. "…temporal dimension and coherence, which addresses the allocation of resources over time and phases implementation in the short, medium and long term." (Bizikova, 2023).

In other words, and with regard to the issue we are addressing, this last dimension in particular should be considered in order to streamline the effectiveness of national educational and health policy in favour of the development of national minorities and their culture and the inclusiveness of language competences. Inclusiveness, openness and linguistic adaptability of the socio-biological system can lead to human beings being able to adapt to changes in the ontological space of their existence. The experience of human beings with *a priori* and standard dice can be practically applied, in combination with knowledge of new and perhaps different situations, through the communicative dimension of human existence. Language is an important foundation of the communicative dimension of human existence. In the context of this article, this link between language, policy coherence and communicative openness is also central to understanding how health and educational systems communicate about complex risks such as AMR in multilingual societies. The ontological space of the human being and the ability to understand it is linked to the linguistic framing of this space and its changes over time, and to differential access to information. The role of language is therefore understood here not only as an educational concern, but as a key determinant of how fluid risks are made visible, negotiated and governed. The role of language is critical and the access and exchange of information is critical in this instance, and all voices that have anything to contribute to the AMR fluid risk. The open system in Thailand, with respect to AMR and the understanding of the fluid risks and intersectionality associated with refugees health and migration patterns in the regions, are closely interlinked. The fluidity of the risk indicates that the situation would optimally be resembling the metaphor and onto-epistemology of the standard dice/die. For that to happen, the Thai society and the public healthcare system would need to listen to all voice in the AMR landscape, e.g. healthcare workers, Thia communities and refugees/migrants who are also patients impacted by the AMR fluid risk.

AMR has been disproportionately impacting LMICs (Pokharel et al., 2024). The delivery of healthcare and public health is often constrained by budgetary restrictions and occurs in low-resource environments. Under such conditions, it is necessary to employ community members who can be trained to work alongside the formal healthcare workforce in tackling AMR. Formal healthcare workers include nurses, doctors, pharmacists and other cadres (Maphumulo & Bhengu, 2019). The community members who are trained to perform certain functions and roles in the public healthcare sector are referred to as community healthcare workers (CHWs; D'Ambruoso et al., 2023). South Africa provides one illustrative example: CHWs have been a part of its healthcare system since the 1930s, having to balance limited resources and competing priorities (Murphy et al., 2021). Between the 1990s and the beginning of the 2000s, there was an increase in the number of CHWs recruited and trained due to the high prevalence of HIV and TB (Nxumalo et al., 2016). Since 2011, South Africa's National Department of Health has made re-engineering the primary

healthcare (PHC) system a top priority. Forming the foundation of the national Ward-Based Primary Healthcare Outreach Teams (WBPHCOT) programme, CHWs, with the assistance of other formal healthcare professionals, serve as a link between communities and services from healthcare facilities (Murphy et al., 2021; Schneider et al., 2018). There has been a substantial shortage of human resources in South African healthcare facilities; the recruitment and placement of approximately 70,000 lay healthcare workers (a broader term under which CHWs fall) by 2010 assisted to some extent in addressing this shortage (Murphy et al., 2021; Schneider et al., 2018). CHWs now have a wide range of responsibilities under the Policy Framework and Strategy for WBPHCOT 2018/19–2023/24, including visiting homes and communities for health promotion and illness prevention (Murphy et al., 2021; Thomas et al., 2021). While the institutional arrangements differ, similar dynamics are evident in other low- and middle-income settings, including Thailand, where constrained resources, task-shifting and community-based health actors are central to public health delivery, particularly in border and migrant-affected areas. The CHWs example provides a way to gain the understanding of the AMR landscape on the ground and closest to the patient. These workers, either CHWs or formal healthcare workers (Sharma et al., 2025), are closets to the tactical or the on-the-ground level of AMR. They are also many time patients themselves. They can function as resource persons for the near-real-time monitoring of the AMR fluid risk. They can help provide a picture of the standard dice/die about the onto-epistemology of the AMR fluid risk on a particular public health area. They can help detect the potential for new resistant strains in refugee and migrant populations. Such resource persons are critical for the complete understanding of AMR landscape, intersectionality and their relationship to the refugee or migrant health in Thailand.

The challenge with AMR is that it is a super-wicked problem (Littmann & Simonsen, 2019; Littmann et al., 2020). Among its many characteristics, time urgency and complexity with no clear solutions are particularly pressing from a public health point of view (Pokharel et al., 2024). From a public health systems perspective, AMR can be understood as the result of a process called emergence. Emergence is a property of complex systems which can be defined, as summarised by the Systems Thinking Alliance (STA, 2024):

> "Emergence is what 'self-organizing' processes produce (Corning, 2002) and refers to the arising of novel and coherent structures, patterns, and properties during the process of self-organization in complex systems."

Based on this definition, AMR can arise from unpredictable interactions in complex and multi-stakeholder public healthcare systems. Formal healthcare workers, who have formal mandates and who need to adhere to legislated functions inside the public healthcare system, might need to deviate from these mandates due to lack of resources or limited knowledge about AMR among both professionals and CHWs. Emergent AMR patterns can also arise from the ever-increasing complexity of

healthcare settings and the conditions under which care is provided. For example, the overuse of a particular antimicrobial agent due to shortage of an alternative antibiotic might lead to the development of AMR in a previously unseen set of circumstances, such as a new resistant strain of a previously antibiotic-susceptible bacterium. Lack of resources, the need to involve ever more healthcare workers in delivering care, as well as other factors in present-day public health systems, all increase systems complexity. This increasing complexity of the landscape of patient care provision by multiple healthcare professionals and CHWs can facilitate the emergence of AMR through shifts in healthcare conduct away from prescribed or legislated mandates as a result of resource shortages. Unknown causal pathways in the complex healthcare system can also contribute to the emergence of AMR. These dynamics are not unique to a specific country; they are also relevant to Thailand's AMR governance landscape, where multiple actors state, private, non-governmental and community-based are operated under resource constraints and uneven access to diagnostic and stewardship support.

Another way to define emergence is to consider a specific subtype of emergence, namely AMR, as the result of novel behaviours among stakeholders in public health systems. This can be summarised by a different definition of emergence proposed by NECSI (2022):

> "Emergence refers to the existence or formation of collective behaviours - what parts of a system do together that they would not do alone".

The development of AMR can thus be understood as arising from changing behaviours among many or most stakeholders in the public healthcare system. For example, the prescribing of antimicrobial agents to patients with viral diseases, or the wrong antibiotic being prescribed for treatment of a particular bacterial causative agent, can contribute to resistance. Changes in patients' behaviour in relation to antimicrobial regimen adherence may also be a source of AMR development, such as discontinuing treatment after symptomatic improvement but before completion of the prescribed course. By applying either of the emergence definitions to AMR management, it becomes clear that it is critical to gather as much information as possible about the factors that shape these behaviours and the conditions under which they occur. The inputs from formal healthcare workers and CHWs are needed to understand the development of AMR and ways to tackle it in a public healthcare system in a specific area. This is necessary to gain the maximum amount of information about the complexity of AMR settings and their development in a given locality, for example in border areas in Thailand, or areas across Thailand with large refugee or migrant populations. General and routine approaches exist to manage AMR in public healthcare systems and may be applicable in many settings, leading to a predictable decrease in the prevalence of AMR. However, local conditions can produce deviations from the patterns that such

routine approaches are designed to address. As a result, it is necessary to study the emergence of AMR under local conditions by engaging a wide variety of stakeholders in the relevant public health system and, in particular, by focusing on the primary healthcare context where the majority of the population accesses care and where triggers and governing factors of AMR are likely to manifest. The same logic applies to AMR in Thailand's health system, particularly in settings where refugees, migrants and stateless persons interact with multiple layers of care—public facilities, private clinics, non-governmental organisations and informal providers. In these contexts, diverse formal and community-based actors may collectively, and sometimes unintentionally, generate emergent AMR patterns through their everyday practices under conditions of constraint and uncertainty. All voices in the public healthcare sector must be heard in relation to AMR and its temporal development. Stakeholders and role players must exchange information on an ongoing basis and the communication dimension of the society must be strong. For Thailand, the refugee and migrant voices are of particular importance, along with their AMR and health intersectionality. Achieving the onto-epistemological understanding this landscape, and keeping it close to the status of the metaphor of the standard dice/die, will require that the refugee and migrant voice are always at the table of the AMR discussion and management. All stakeholders must also be at the that table, and actively engaged in the open communication and information exchange, in collaborative AMR management. If any voice is not represented, then it should be heard through epistemologically well informed resource persons. The next section of the article will focus on the mechanism to achieve this in practice. The relevant set of voices will also be engaged on.

6. Communicative ecology and intersectionality in Thailand's AMR and refugee-migrant settings

If Sections 4 and 5 described how fluid risk emerges within socio-biological systems, this section specifies how those systems are organised and experienced in Thailand using the concepts of communicative ecology and intersectionality. A successful approach to the tackling of AMR should be based on all voices being heard and the need for the continuing engagement of the AMR stakeholders in a particular area. As Stokoe et al. (2024) noted, it is important for participants in a forum of public health relevance to be engaged. The authors studied an online chat in a biomedical conference to measure participants' engagement in the proceedings (Stokoe et al., 2024). This is a very specific situation and communication avenue analysis, but it provides a useful demonstration of the need for stakeholders in a public health setting to engage across potential barriers, e.g. physical separation and differences in available language/linguistic tools. Professional background and mandates can also be a form of barrier. Using communication across such perceived barriers can help scope and advance the understanding of super-wicked problems such as AMR (Pokharel et al., 2024).

In Thailand, these theoretical lenses translate into a dense but identifiable landscape of actors who shape how AMR is governed and experienced. In Thailand, this logic becomes particularly important when AMR is treated as part of the national disaster risk profile rather than only as a clinical problem. Mapping all AMR stakeholders within this profile is necessarily complex and will be developed further in subsequent work, but at minimum it spans national ministries and departments responsible for human and animal health, agriculture, food and drug regulation, water resources, environmental management and disaster risk reduction. These mandates are then operationalised through provincial and district-level offices and line agencies not only health offices, but also agricultural extension, local administration, water and sanitation and related services that together shape how antibiotics are regulated, supplied, monitored and discharged into the environment. Within the state system, this extends down to clinicians, pharmacists and public health officers. It also includes community-facing actors such as Migrant Health Workers (MHWs), Migrant Health Volunteers (MHVs) and Village Health Volunteers (VHVs), who mediate between formal services and communities in both Thai and non-Thai populations. External to the Thai government, but closely interacting with it, are non-governmental and humanitarian organisations involved in service delivery, such as The Border Consortium (TBC) in the Thai-Myanmar border region, as well as regional and international actors such as ASEAN's One Health and disaster risk reduction initiatives and UN agencies.

Within this broader landscape, refugees and migrants along the Thai–Myanmar border and in urban centres represent settings in which several AMR drivers coincide: high human mobility, uneven access to formal health services, over-the-counter or informal antibiotic use, and environmental conditions shaped by housing and WASH infrastructures (UNHCR Thailand, 2023; IOM, 2024a; WHO, 2024). Many displaced groups move through what some methodologies describe as "statistical silence", remaining largely outside routine surveillance and public health planning (IOM, 2024b; Castañeda Aguilar et al., 2024). From a disaster-risk perspective, these populations therefore constitute community ecologies in which AMR can accumulate quietly as a slow-onset hazard rather than a discrete event. Creating forums and communication channels in which actors across this system…from national authorities to border clinics, volunteers and displaced communities…can share their observations of antibiotic access, use and treatment outcomes is essential for making such slow-onset risks visible and for identifying context-appropriate ways to manage AMR. The evaluation of the healthcare system at the policy level, through the identification of relevant stakeholders in the AMR management which includes refugee and migrant considerations, through investigation into the mechanisms or lack thereof for resource and information sharing. In this way, it is possible to ascertain the openness or closeness of the Thai public healthcare system. BY examining the evolution of the public healthcare system and its dealing with risks, it is possible to gain understanding

of the reaction and adaptation to new challenges and possible shifts from a priori to standard dice/die. This is critical to gain full understanding of the onto-epistemology of AMR in the country and how refugee/migrant population contribute to it.

Understanding emergence and temporal changes in the properties of AMR requires combining the viewpoints and listening to the voices of multiple stakeholder groups. These include formal healthcare professionals (nurses, pharmacists, medical doctors and assistant personnel), community-based cadres who provide primary-level services, and actors who work at the interfaces between state systems, humanitarian structures and displaced communities. This article draws on the concept of communicative ecology, defined by Foth and Hearn (2007) as

> "'communicative ecology' as a concept which integrates the three dimensions of 'online and offline', 'global and local' as well as 'collective and networked'".

One of the original interpretations of communicative ecology was proposed for the online and social media context (Foth & Hearn, 2007), but it can be extended to human-to-human interaction and network-based problem solving. In the context of AMR in Thailand, the 'online and offline' dimension can be understood as the relationship between formal, documented channels of information—such as national AMR surveillance systems, laboratory reporting, clinical guidelines and committee deliberations and the everyday knowledges that circulate in clinics, border camps and communities. 'Online' in this sense includes the views and observations of clinicians, pharmacists, laboratory staff and officials whose practices are recorded in hospital information systems, NARST reports and national action plan monitoring. 'Offline' refers to perspectives from the interface between formal systems and everyday life: Migrant Health Workers and Migrant Health Volunteers, Village Health Volunteers, NGO and humanitarian clinic staff, community leaders and refugees and migrants themselves, who may provide or receive antibiotics in ways that are rarely captured in formal datasets but are central to how AMR risk is lived and negotiated.

The 'global and local' dimension, when applied to Thailand's AMR and refugee–migrant settings, links global framings of AMR as a One Health and disaster risk issue, as articulated through WHO guidance, ASEAN initiatives and international humanitarian standards with local conditions along the Thai–Myanmar border and in Thai urban areas. At the local level, AMR is shaped by specific care pathways, language practices, regulatory enforcement, antibiotic supply chains, livestock and aquaculture practices, water and sanitation infrastructures and the legal status of displaced populations. Communicative ecology draws attention to how these global and local narratives and data streams meet, reinforce or contradict one another in concrete places (Mae Tao Clinic, n.d.; The Border Consortium, 2023).

Finally, the 'collective and networked' dimension highlights that AMR in Thailand emerges from the interactions of multiple, partly overlapping networks: networks of

ministries and departments, provincial and district offices, healthcare facilities and laboratories; networks of volunteers, community-based workers and camp or settlement committees; networks of non-governmental and humanitarian organisations such as The Border Consortium; and transnational policy and funding networks in which AMR, displacement and disaster risk reduction are discussed together. Analysing AMR through this communicative ecology lens makes it possible to see how different actors' positions in these networks condition whose risk perceptions, experiences and proposed solutions are amplified, and whose remain marginal or silent, particularly in relation to refugees and migrants. This, in turn, informs the fluid onto-epistemology developed in this article by specifying the communicative structures through which AMR is problematised and made actionable in Thailand.

Intersectionality, as articulated by Collins and Bilge (2020), provides an additional lens for understanding how AMR risk is distributed and perceived within Thailand's refugee and migrant settings. Rather than treating "refugees" or "migrants" as homogeneous categories, an intersectional perspective attends to how multiple axes of social positioning…such as legal status, gender, livelihood, language, geography and professional role. These aspects combine to shape both exposure to AMR drivers and participation in the communicative networks through which AMR is rendered visible. In the context of this article, intersectionality is not employed primarily as a framework for individual identity, but as an analytical tool for examining how different positions within Thailand's socio-biological systems condition who encounters which combinations of antimicrobial use, surveillance, infrastructure and constraint, and whose experience of these combinations can enter policy and governance discussions.

An intersectional perspective makes it possible to differentiate between displaced and mobile populations who are often treated as a single category. Along the Thai–Myanmar border and in Thai urban areas, displaced and mobile populations occupy a range of legal and administrative categories, including registered refugees in camps, people in temporary safety areas, documented and undocumented migrant workers, stateless persons and Thai citizens with migrant family ties. These categories intersect with place (camp, border town, rural settlement, city neighbourhood), gendered and age-based care roles, language repertoires (Thai, Burmese, Karen and other languages) and forms of livelihood (agricultural labour, factory work, informal trade, domestic work). Together, they influence access to formal health services, patterns of reliance on NGO or humanitarian clinics, the use of over-the-counter or informal antibiotics, and the degree of dependence on water, sanitation and housing infrastructures that may be more or less conducive to the circulation of resistant organisms. For example, a documented migrant working in a factory near a district hospital, able to communicate in Thai, may encounter a different configuration of antibiotic prescribing, diagnostic access and follow-up than an undocumented worker

in a remote agricultural area, or a camp-based carer whose primary point of contact is a camp clinic or community-based provider.

Within the communicative ecology outlined above, these intersectional positions also structure who appears in "online" channels, such as surveillance datasets, formal reporting lines and national committee deliberations. They remain largely "offline", present mainly in tacit knowledge, local narratives and unrecorded practices. Medical doctors, pharmacists and laboratory staff in government facilities are more likely to contribute to NARST data and to participate in formal AMR policy processes; by contrast, Migrant Health Workers, Migrant Health Volunteers, Village Health Volunteers, NGO and humanitarian clinic staff, informal medicine sellers and displaced patients often operate at the margins of these formal channels, even when they are central to the day-to-day circulation of antibiotics. Intersectionality helps to specify how combinations of legal status, language, occupational mandate and spatial location make it more or less likely that particular experiences of treatment failure, self-medication, stock-outs or perceived "ineffectiveness" of medicines will be recorded, translated and acted upon. In this sense, some intersectional constellations—for example, undocumented status, non-Thai language, residence in camp or informal housing, reliance on informal providers—are more closely associated with what has been described as "statistical silence", in which populations are present in the epidemiological reality of AMR but largely absent from routine surveillance and risk planning. Incorporating an intersectional lens into the communicative ecology of AMR in Thailand therefore clarifies not only who is most exposed to fluid, slow-onset AMR risks, but also whose voices need to be intentionally sought if the emerging framework is to function as a realistic tool for disaster risk profiling and subsequent empirical work.

Taken together, the actors and positions described above are not only a list of stakeholders, but the components of a communicative ecology through which AMR is problematised and governed in Thailand. At the national level, this ecology is structured by ministries and departments with mandates for human and animal health, agriculture and food production, pharmaceutical regulation, water resources, environmental protection and disaster risk reduction. These include, among others, the Ministry of Public Health, the Ministry of Agriculture and Cooperatives, and the Ministry of Natural Resources and Environment. Within these institutions, AMR is framed and coordinated through instruments such as the Thailand National Strategic Plan on Antimicrobial Resistance 2017–2021 and its successor action plan, disease-control regulations, drug scheduling frameworks and national disaster risk management strategies that increasingly acknowledge biological hazards and One Health perspectives (Ministry of Public Health & Ministry of Agriculture and Cooperatives, 2017; National AMR Committee, 2023; Sumpradit et al., 2021). These high-level arrangements are not merely technical; they establish which forms of AMR data and expertise are considered

authoritative, how responsibility is distributed across sectors and where AMR is located within Thailand's broader risk governance architecture.

These national mandates are then operationalised through provincial and local administrative structures. Thailand's unitary but decentralising system distinguishes central administration from local government, with the latter comprising Provincial Administrative Organizations (PAOs), municipalities and Tambon Administrative Organizations (TAOs), alongside special forms such as the Bangkok Metropolitan Administration and Pattaya City (Varanyuwatana & Laovakul, 2010). In practice, provincial public health offices, regional and provincial hospitals, regional disease control offices and provincial livestock and fisheries offices translate national AMR and One Health strategies into surveillance, stewardship and infection-prevention activities (Sumpradit et al., 2021). Local governments—PAOs, municipalities and TAOs—contribute through responsibilities for water supply, wastewater and solid-waste management, environmental quality and aspects of local agricultural and aquaculture oversight, all of which are increasingly recognised as relevant to environmental AMR (Ministry of Public Health & Ministry of Agriculture and Cooperatives, 2017). Within healthcare and public health, clinicians, pharmacists, public health officers and laboratory staff in government and contracted facilities enact guideline-based practices, generate surveillance data and participate in hospital and provincial AMR committees or working groups. Community-facing actors such as Migrant Health Workers (MHWs), Migrant Health Volunteers (MHVs) and Village Health Volunteers (VHVs) translate these policies and clinical norms into everyday encounters, often negotiating between official expectations and local realities in both Thai and non-Thai populations.

External to the state, but closely intertwined with it, are non-governmental organisations. In the Thai–Myanmar border region, organisations such as The Border Consortium and Mae Tao Clinic deliver services and advocacy that shape antibiotic access, treatment pathways, and data flows for displaced and migrant populations (Mae Tao Clinic, n.d.; The Border Consortium, 2023). At the regional level, ASEAN's Strategic Framework to Combat AMR and emerging One Health initiatives provide guidance and coordination for member states, while at the global level agencies such as WHO and FAO support multisectoral AMR and One Health action plans (ASEAN, 2019; ASEAN Leaders, 2023; Food and Agriculture Organization of the United Nations [FAO], 2021; World Health Organization, 2015). From a communicative ecology perspective, this multi-level, multi-actor architecture can be understood as a set of overlapping networks through which information, norms and resources about AMR circulate.

Some nodes, e.g. such as national committees, surveillance laboratories, or large hospitals are highly visible and central in terms of data production and policy influence. Others…such as camp clinics, informal medicine sellers, volunteers, or displaced patients…occupy more peripheral positions, contributing tacit knowledge

and local practices that are rarely captured in formal reporting. The alignment or misalignment between these networks, and between national policy narratives and local experiences, shapes which configurations of AMR risk become legible as matters of concern and which remain background conditions in everyday life. Conceptualising stakeholders and policy instruments in this way reinforces the article's argument that AMR in Thailand should be read not only as a biological phenomenon, but as an emergent property of socio-biological systems whose communicative structures help determine how fluid, slow-onset risks are recognised and addressed.

Bringing these strands together, communicative ecology and intersectionality specify how AMR as a fluid risk is experienced and governed within Thailand's refugee- and migrant-affected settings. The dice metaphor and the notion of fluid ontological space highlight how everyday life in these settings oscillates between more predictable and radically uncertain configurations of antimicrobial risk. The distinction between open and closed socio-biological systems, and the mapping of stakeholders and policy architectures, show how national and subnational arrangements can either stabilise or obscure emerging AMR patterns. Communicative ecology then traces the networks through which knowledge, norms and resources about AMR circulate, while intersectionality clarifies how different positions within those networks condition exposure, visibility and voice. Together, these lenses complete the theoretical work of this section: they locate AMR in Thailand not only as a microbiological phenomenon, but as a slow-onset, super-wicked disaster emerging from the interaction of socio-biological systems, communicative structures and intersectionally positioned actors. In doing so, they provide the conceptual scaffolding for the empirical work that will follow, indicating which sites, stakeholders and knowledge flows must be engaged if AMR is to be understood and governed as part of Thailand's broader disaster risk profile.

The investigations in the nature of the AMR in the border and migrant-holding areas will be based on communicative ecology of all voices, or well-informed resource persons as surrogates for silent or statistically missed refugee and migrant impacts. IN this way, the onto-epistemological understanding of the AMR management can be achieved and optimized.

7. Synthesis: a fluid onto-epistemology of AMR in Thailand

This article has developed a fluid onto-epistemology of AMR in Thailand, understood as a way of thinking that keeps together the realities of human existence, the dynamics of risk and the forms of knowledge through which AMR is perceived and acted upon. The analysis began by situating AMR as a complex problem in healthcare and beyond, emphasising its character as a super-wicked, temporally urgent and globally uneven hazard. It then framed AMR as a bioethical and uncertainty challenge, drawing attention to tensions around justice, responsibility and the distribution of harms and

benefits. On this basis, the article introduced the notion of a fluid onto-epistemology as its central contribution, outlining three aims: to conceptualise AMR as a fluid, super-wicked risk embedded in human and socio-biological systems; to articulate a set of theoretical lenses capable of capturing that fluidity; and to apply these lenses to Thailand's AMR governance, with particular attention to refugee- and migrant-affected settings, in order to guide subsequent empirical work.

The subsequent sections elaborated this framework through four interlocking lenses. First, the theoretical framework for fluid risk combined risk society, the ethics of metaphors and ampliative reasoning, and intersectionality to show how late-modern risks such as AMR are manufactured, recognised and narrated, and how metaphors like the three dice can make complex, shifting risk landscapes intelligible without reducing them to simple probabilities. Second, the analysis of open and closed socio-biological systems and knowledge flows situated AMR within the physical, cultural and communicative dimensions of human existence, highlighting how emergence arises from interactions among constrained resources, institutional mandates and everyday practices in health systems. Third, the communicative ecology lens was proposed as a way to map the multi-level architecture of Thai AMR governance, from national ministries and strategic plans to provincial and local administrations, volunteers, NGOs and regional bodies, while the intersectionality lens clarified how legal status, language, place, livelihood and professional role shape both exposure to AMR drivers and participation in AMR-related communication. Taken together, these lenses describe AMR in Thailand as an emergent property of socio-biological and communicative systems, rather than as an isolated technical problem.

This fluid onto-epistemology has practical implications for future empirical work and for AMR risk governance. Conceptually, it suggests that studying AMR in Thailand's refugee- and migrant-affected settings requires attending simultaneously to microbiological data, patterns of antimicrobial use, institutional mandates, communicative networks and intersectional positioning. Methodologically, it points towards multi-sited and multi-stakeholder approaches that engage actors across the formal health system, local administrations, community-based providers, humanitarian organisations and displaced communities themselves, and that treat both formal surveillance and lived experience as sources of knowledge about AMR emergence. From a policy perspective, the framework encourages Thai and regional stakeholders to read AMR as part of the country's disaster risk profile—linked to water, environment, mobility and governance—rather than solely as a hospital-based clinical outcome. In this way, the fluid onto-epistemology developed here is intended not only as a conceptual contribution, but as a guide for designing, interpreting and communicating empirical research on AMR in Thailand's refugee and migrant health systems, and for informing disaster risk governance decisions that must account for AMR as a slow-onset, super-wicked disaster.

Conclusions

This article establishes a fluid onto-epistemology to address AMR, framing it not merely as a clinical challenge but as a super-wicked, slow-onset disaster embedded in socio-biological systems. By employing a probabilistic three dice metaphor framework, captures how AMR risks fluctuate between predictable statistical probabilities and radical, catastrophic uncertainty. When applied to Thailand, specifically within refugee- and migrant-affected settings, the study utilizes 'communicative ecology' and 'intersectionality' to reveal how factors like legal status, language and all voices of AMR being heard shape both exposure to risk and the visibility of that risk in formal data and the AMR management by the public healthcare system in Thailand. The authors conclude that effective governance requires integrating formal surveillance with the tacit knowledge of community-based actors, ultimately treating AMR as a critical component of national disaster risk profiles to better protect marginalized populations.

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