

**Exploring the governance of antimicrobial stewardship and deep pandemic
prevention: from siloed approaches to integrative governance models informed
by urban political ecology**

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Dissertation abstract

Governance of infectious disease prevention and antimicrobial resistance (AMR) share similar implementation challenges. Exploring the governance of antimicrobial stewardship and deep pandemic prevention that involves wildlife trade regulation as a source of zoonotic spillover may inform approaches to address AMR and other threats at the human-animal-environmental interface.

This dissertation aims to explore governance models that adopt a One Health (OH) lens to address the governance of infectious disease prevention and AMR through (i) assessing the role of wildlife trade regulatory approaches in the prevention of zoonotic spillover and infection transmission, (ii) mobilizing an urban political ecology (UPE) lens to assess the under-exposed dimensions and interdependencies of AMR, and (iii) deploying a UPE lens to inform the analysis of peer-reviewed literature on implementation of OH-AMR governance approaches.

To assess the role of wildlife trade regulatory approaches in the prevention of zoonotic spillover and infection transmission, a scoping review was conducted to identify and describe studies discussing different trade standards and regimes governing wildlife trade. To assess under-exposed urban dimensions of AMR and to inform AMR governance strategies, an interdisciplinary analysis was conducted to bridge the epistemic domains of UPE and OH. Lastly, a critical interpretive synthesis (CIS) of peer-reviewed literature was conducted through a UPE lens to clarify the extent to which OH-AMR governance responses institutionalize coordinated AMR-environmental approaches to address challenges and concerns.

Governance of infectious diseases prevention in wildlife trade involves institutional and regulatory purviews concerning zoonotic spillover prevention characterized by fragmentation and lack of oversight by a single global coordination authority. The deployment of a UPE lens as a guide to practical politics of sustainability and human-nature relationships contributes to an understanding of how AMR and other systemic threats may be confronted in policy and practice. A UPE-informed analysis of literature discussing AMR governance arrangements reveals opportunities and limitations to simultaneously generate health and environmental gains for targeted populations.

Mobilization of an OH approach that considers intersectoral linkages between wildlife trade and complex socioecological interactions that produce the interfaces where zoonotic spillover occurs may improve information sharing and intersectoral governance that contributes a better understanding of the role of global and national organizations in preventing zoonotic spillover and transmission.

In an urbanized and interconnected world, a UPE lens illuminates the interconnections among urban life, AMR risks, other global health threats, and aligns with calls to rescale governance arrangements by better taking societal relations with nature into account. More research is needed to consider the feasibility and relevance of designing intersectoral OH-AMR approaches informed by the UPE of AMR.

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List of acronyms and abbreviations

ADMER	Antibiotic Drug Use, Monitoring and Evaluation of Resistance Project
AM	Antimicrobial
AMR	Antimicrobial Resistance
AMU	Antimicrobial Use
ASP	Antimicrobial Stewardship Program
CBD	Convention on biological diversity
CIS	Critical Interpretive Synthesis
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CODEX	Codex Alimentarius
DANIDA	Danish International Development Agency
FAO	United Nations Food and Agriculture Organization
GAP	Global Action Plan
GHSA	Global Health Security Agenda
HICs	High income countries
IHR	International Health Regulations
ILRI	International Livestock Research Institute
IPC	Infection Prevention and Control
IPPC	International Plant Protection Convention
IUCN	International Union for Conservation of Nature
LMICs	Low and Medium income countries
NAP	National Action Plans
NPAR	Ghana's National Platform on AMR
OH	One Health
PHEIC	Public Health Emergencies of International Concern
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta
SAPG	Scottish Antimicrobial Prescribing Group
SDGs	Sustainable Development Goals
SIDA	Swedish International Development Agency
SPS	Sanitary and Phytosanitary
SR	Scoping Review
STRAMA	Swedish Strategic Programme for the Rational Use of Antimicrobial Agents
TRAFFIC	Wildlife Trade Monitoring Network
UHC	Universal Health Coverage
UK DFID	United Kingdom Department of International Development
UN	United Nations
UNEP	United Nations Environment Program
UPE	Urban Political Ecology
USAID	United States Agency for International Development
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization
WOAH	World Organization for Animal Health
WTO	World Trade Organization

Chapter 1 Introduction

Governance of infectious diseases prevention and antimicrobial resistance (AMR) share similar implementation challenges. AMR is regarded as a leading cause of death globally, with recent estimates showing that resistant bacteria caused or contributed to nearly 5 million deaths worldwide in 2019 (1). AMR threatens animal and ecosystem health, the viability of food systems, agriculture, farming, water, hygiene and sanitation systems (2–6). It represents a threat not only to human health, but to society and the systems upon which it depends. Public AMR responses at the human-animal-environmental health interface have been characterized as fragmented and lacking in intersectoral coordination, necessitating enhanced intersectoral collaboration (7–10).

Global health governance responses to threats posed by zoonotic diseases at the human-animal-environmental health interface, such as wildlife trade, is also characterized by fragmentation and lack of oversight by a single coordination authority. Wildlife trade can create adverse impacts for global biodiversity and human health, including increased risks for zoonotic spillover that may lead to pandemics (11). Wildlife trade provides many opportunities for infectious disease to be transmitted from animals to human handlers (i.e., zoonoses) by increasing the human-animal-environment interface (12). The important risks of both the legal and illegal wildlife trade for public health have been under heightened scrutiny for their zoonotic transfer potential, and research suggests the pivotal role of wildlife trade in spillover events, such as the role of the Huanan Seafood Wholesale Market as the source or spreader event that led to the COVID-19 pandemic (11).

Governance models for single-issue international or transnational regimes no longer capture governing arrangements for many of the most pressing global environmental problems (9), including global health threats linked to AMR, such as climate change, pandemics, pollution, and biodiversity degradation. Measures addressing these threats have been governed by arrays of mechanisms including legal, non-legal, governmental, and non-governmental arrangements that may require governance arrangements and rationales that move away from policy compromises or economic optimization (9,13), to focus on enabling environments (14) informed by theory-guided approaches that allow more systematic, effective and sustainable interventions (15,16). Individuals and institutions, public and private, can manage conflicting or diverse interests through intersectoral governance (10).

The One Health (OH) approach to sustainably balance and optimize the health of people, animals and ecosystems has been increasingly adopted in academia, by the public sector and international organizations seeking to address similar intersectoral challenges (17). While global health responses can draw on a variety of OH tools to simultaneously address AMR and other OH threats (18–21), the institutionalization of OH governance arrangements face coordination, design and conceptualization challenges (7–10,22–27). This manuscript-based dissertation used different qualitative methods to gain an understanding of possible governance models that adopt a OH approach to address the governance of AMR and prevention of infectious diseases in the wildlife trade.

The first stage of the research was to conduct a scoping review (SR) to identify and describe peer-reviewed studies conducted on regulatory approaches that govern

domestic and international wildlife trade to assess the role of local, national and global-level institutions in the prevention of zoonotic spillover and infection transmission between humans. The 21 articles included in the SR indicates that regulations governing wildlife trade are inconsistent within and between countries, suggesting the need for enhanced regulatory harmonization. The second stage involved interdisciplinary research to integrate Urban Political Ecology (UPE) as a theory for identifying under-exposed urban dimensions of AMR. Bridging the epistemic domains of UPE and OH allows the conceptualization of urbanization as a ubiquitous socioecological process and an interpretive frame that situates AMR risks in relation to socioecological dimensions, and that informs AMR governance strategies across related contexts.

In the third stage, we mobilized UPE lens to inform a critical interpretive synthesis (CIS) of OH-AMR governance arrangements, with the purpose of clarifying the extent to which scientific literature has situated OH-AMR governance responses in relation to socioecological challenges and concerns typically explored through a UPE lens. Findings from the 18 studies included in the CIS reveal insights from authors that recognize opportunities and limitations to simultaneously generate health and environmental gains for targeted populations, while offering a compelling case for the adoption of a UPE lens to inform future efforts in addressing AMR and related global health challenges.

1.2. Rationale for this Study

AMR, pandemics, biodiversity degradation and climate change pose simultaneous existential threats (28–30), yet coordinated responses that jointly address

them do not currently exist. As AMR rates are projected to increase from twenty-five percent to forty percent by 2050 (31), integrating antimicrobial (AM) stewardship measures within broader development policies and plans aimed at environmental sustainability is imperative. Past experience and current research indicate that approaches to reduce AMR and spread of infectious diseases (IDs) premised on a biomedical security logic of surveillance and behavioural change are not effective, as they obscure the role of social determinants and neglect the impacts of ecological deterioration and the climate crisis on AMR risks in an urbanizing world (24,25,27,32).

Enhanced governance responses must contend with complex interactions of naturally occurring microbial evolutionary processes, and anthropogenic pressures on planetary health systems that accelerate AMR and ID. Despite knowledge gaps underlying the dynamics and causal complexity of AMR proliferation in the environment, there is currently enough evidence showing that the environmental AMR is influenced by anthropogenic activities “damaging the natural microbial world – the very foundation of global ecology” (21). Indeed, academics and international organizations have made explicit connection between nature-society relations as they relate to urbanization forms and processes, environmental degradation, climate change, biodiversity loss, and emerging AMR and pandemic threats (4,33–36).

Environmental AMR – therefore – cannot be understood or addressed separately from these challenges (21), as drivers of environmental degradation may continue to impose pressures on planetary health systems that accelerate AMR. This recognition creates new opportunities for enhanced AM stewardship, calling for integrated governance approaches that foster improved AM stewardship.

As national governments adopt whole-of-government approaches to address the threat of climate change (37,38), integration of AM stewardship within extant and expanding environmental stewardship may present opportunities to leverage whole-of-government AM-Environmental stewardship measures that support pandemic prevention and produce co-benefits to human and planetary health. Under the current logic of technical and market integration (26), however, the operationalization of whole-of-government intersectoral governance responses to address systemic risks poses complex challenges. Siloed approaches to human and animal health, agriculture, and the environment produce externalities and instigate intersectoral and international recalcitrance (39).

Situating the design and operationalization of shared governance responses in relation to drivers shaping the socioecological determinants of these existential threats would support reinvigorated and clear institutional mandates with potential to collectively realize equity and environmental gains.

In this context, governance approaches to address AMR must be able to contend with the climate crisis while aiming to progressively redress nature-society relations associated with this threat. Theoretical frameworks informing an enhanced governance response would leverage antimicrobial use (AMU) and AMR responses to support measures addressing the health inequities and environmental injustices triggering AMU and accelerating AMR.

Despite progress in the implementation of OH approaches to address AMR (40–43), and growing recognition of the co-benefits generated by measures jointly addressing human-animal-environmental health (44–47), operationalization of AM

stewardship lacks a theory (48) informing how OH-AMR governance responses could simultaneously address climate change, health equity and environmental justice, as enshrined in the definition of OH (17,19).

UPE scholarship proposes a critical approach that considers human-nature relations as non-linear and mutually constitutive processes shaping a politics of sustainability, as they relate to climate change and environmental degradation in a predominantly urban world. Given the evolution and growing transmission of AMR, policymakers recognize the interdependencies of AMR, climate change and environmental degradation, and the need to address these threats through a whole-of-government and whole-of-society approach (21,49–53).

UPE addresses connections between anthropogenic pressures and the political ecologies of AMR risks that transcend state and national borders, offering a theory of change that situates the acceleration of AMR in relation to existential threats already confronted in broader commitments to pandemic prevention and environmental stewardship. Reliance on shared governance pathways informed by UPE scholarship present an opportunity to engage global political and economic forces shaping the social and political co-determinants of AM threats and environmental degradation.

The complex challenges posed by the operationalization of AM-Environmental stewardship challenges leaders to build and sustain a vision of a more equitable and environmentally just future. By exploring the governance of AM stewardship and deep pandemic prevention that involves wildlife trade regulation, this manuscript-based dissertation aims to contribute to the realization of that vision by supporting the effective

integration of governance approaches addressing AMR, IDs and environmental hazards across OH sectors and beyond.

1.3 Research Objectives

Building on governance theory that incorporates a UPE lens to critically enhance the institutionalization of OH-AMR strategies and global governance arrangements, the main objective of the dissertation is to address the governance of ID prevention and AMR by gaining an understanding of possible governance models that adopt a OH approach. Through an OH lens, this dissertation explores the governance of AM stewardship and deep pandemic prevention that involves wildlife trade regulation as a source of zoonotic spillover. Specifically, the three manuscripts comprising this dissertation aim to:

- I. Identify and describe regulatory approaches governing wild animal markets, including their wildlife supply chains, to understand current regulatory frameworks governing wildlife trade as an important step for effective zoonotic spillover prevention measures at the human-animal-environmental interface.
- II. Integrate UPE as a theory for identifying under-exposed urban dimensions of AMR to offer theoretical depth to explore the sociopolitical ecologies of AMR, and to inform governance strategies addressing the upstream structural drivers of AMR and interconnected environmental threats.
- III. Clarify the extent to which scientific literature has situated OH-AMR governance responses in relation to the five socioecological UPE dimensions affecting the outcomes of AMR interventions.

1.4 Organization of the dissertation

This manuscript-based dissertation contains three substantive chapters that have each been formatted as manuscripts for publication. Chapter 2 addresses the first objective of this dissertation, through a scoping review of studies conducted on regulatory approaches that govern domestic and international wildlife trade to assess the role of local, national and global-level institutions in the prevention of zoonotic spillover and infection transmission between humans. Chapter 3 aligns UPE scholarship with OH, bridging two epistemic domains to explore the impact of urbanization for AMR, addressing the second objective of this dissertation. Chapter 4 consists of a critical interpretive synthesis of OH-AMR governance approaches informed by UPE scholarship. Chapter 5 presents an integrated discussion of the overall significance and contribution to knowledge of each manuscript in the context of the entire body of work, including a summary of key research findings, implications for policymakers, points for future research, limitations and a conclusion. The following chapters are introduced by a brief preface with a text connecting manuscripts as an integrated whole, a text indicating the contribution of co-authors, and related appendices and approvals.

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Chapter 2 - Preventing zoonotic spillover and infection transmission through regulatory frameworks governing wildlife trade: a scoping review

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2.1 Preface

Contribution of Authors

RA conceptualize the research questions and study design with support from MW. RA devised the search strategy, acquired, analysed and interpreted the data with support from MW. RG assisted with study selection, data analysis and description of methods. RA wrote the first draft of the manuscript with substantive revisions from MW. MW, RG, and RA developed and reviewed the data chart, with inputs by EG to confirm relevance and to ensure quality of the data extracted. MW, AR, EG, CCA, RL, and RG revised the manuscript and provided substantive inputs. PT and AMV contributed to this manuscript equally by providing inputs and advice. All authors have read and approved the final manuscript.

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2.2 Abstract

Purpose: Wildlife trade can create adverse impacts for global biodiversity and human health, including increased risks for zoonotic spillover that can lead to pandemics.

Institutional responses to zoonotic threats posed by wildlife trade are diverse; understanding regulations governing wildlife trade is an important step for effective zoonotic spillover prevention measures. In this review, we focused on studies conducted on regulatory approaches that govern domestic and international wildlife trade in order to assess the role of local, national and global-level institutions in the prevention of zoonotic spillover and infection transmission between humans.

Methods: The five-stage scoping review protocol described by Arksey and O'Malley to map key concepts and main sources and types of evidence available was followed to understand and analyze empirical evidence from studies conducted on regulatory approaches that govern domestic and international wildlife. Articles were included if they discuss at least one of three points: regulatory approaches governing the wild animal trade, including wild animal markets, traditional medicine or exotic pets; regulatory approaches governing importation of wild animals and the international wildlife supply chain; or the role of local, national, and global-level institutions in regulating wild animal trade for food, traditional medicine or exotic pets.

Results: A total of 620 articles were retrieved, from which 21 articles were included in the final review. Based on published literature, regulations governing wildlife trade are inconsistent within and between countries. Organizations regulating wildlife trade may have competing interests, which can lead to fragmentation and a lack in coordination and oversight. National compliance with international regulations can be an issue.

Conclusion: Reducing the probability of spillover events in wildlife trade is key to prevent future pandemics. Our results indicate a need for enhanced regulatory harmonization within and between national and supranational regulations. Coordination and collaboration for prevention of zoonotic infection and spillover may be enhanced through future research focused on the effectiveness of timely information sharing and global- and national- level harmonization of wildlife trade regulations.

Keywords: regulations, pandemic, information sharing, coordination

2.3. Introduction

With the advent of the COVID-19 pandemic, the public health impacts of wildlife trade are increasingly being studied (1,2), including recent scholarship on zoonotic linkages of emerging and re-emerging infectious diseases (3). Infectious disease outbreaks, epidemics, and pandemics have become more frequent, with SARS, influenza, Ebola, Zika, dengue, and plague outbreaks all occurring within about a 15-year period (4). Approximately 75% of emerging and re-emerging infectious diseases are of zoonotic origin (5); while the origin of SARS-CoV-2 is not definitively known, the zoonotic hypothesis gained much support, with bats believed to be the host and pangolins or racoon dogs as potential intermediate hosts (6–8). Research also shows that early COVID-19 patients resided significantly closer to the Huanan Seafood Wholesale Market in Wuhan, suggesting the pivotal role of wildlife trade in spillover events and of the market in Wuhan as the source or spreader event that led to the COVID -19 pandemic (9).

Panel: definition of key concepts

Regulatory approaches is used to describe different trade standards, regulations and regimes governing wildlife trade

Wild animal markets represent the different types of markets where wildlife trade occurs, such as live-animal markets, wildlife markets, wet markets

Zoonotic spillover is understood as *the processes that enable a pathogen from a vertebrate animal to establish infection in a human* (29)

Exotic pet, sometimes referred to exotic animal or wild pet, is an animal of a non-native or not regularly domesticated species in the country, that is kept or traded for entertainment or company (30)

Traditional medicine is the sum total of the knowledge, skill, and practices based on the theories, beliefs, and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness (31)

Wildlife trade includes trade in traditional medicine products and exotic pets (see panel), and it can be defined as the domestic and international economic exchange of wildlife whose purpose includes consumption by humans, comprising full supply chains, from harvest (which may or may not entail killing) to points of sale to consumers, including markets and restaurants (10). In economic terms, the global trade in wildlife has increased 500% in value since 2005, and 2000% since the 1980s (11). From 1997 to 2016, the legal trade was worth between US\$2.9 to 4.4 trillion (12). The illegal wildlife trade, on the other hand, is estimated to involve US\$7-23 billion each year (12). The demand for wildlife products for use in traditional medicines are worth US\$60 billion annually, and expected to increase to US\$123 billion in China alone by 2023 (13). Wildlife trade provides many opportunities for infectious diseases to be transmitted from animals to human handlers (i.e. zoonoses) by increasing the human-animal-environment interface (14). The important risks of the legal and illegal wildlife trade for public health cannot be ignored.

Regulatory approaches (see panel) addressing threats posed by zoonotic disease include wildlife trade bans that carry significant cultural, development, economic, and health implications (15–17). Targeted mitigation approaches for wildlife markets have included temporary closing (18,19), improved market biosecurity measures (20), bans of trade for specific classes of wildlife (21), and specific interventions related to supply, transport, sale, consumption, and environmental critical control points (22).

Furthermore, live-animal markets, wildlife markets and wet markets are often conflated (see panel), obscuring important differences in risk management approaches

for these different market types, potentially leading to negative consequences such as xenophobic discrimination (16,23). Despite the fact that the Huanan market contained a wet, live-animal, and wildlife market, each of these markets have different characteristics. Live-animal markets sell live wild and domesticated animals, whereas wildlife markets sell non-domesticated wild animals which were either captive-bred or wild-caught. Live-animal and wildlife markets also sell animals for use as pets. Wet markets, in turn, sell consumption-oriented and perishable goods in a non-supermarket setting (23).

Institutional responses to the COVID-19 pandemic in the form of pandemic preparedness and response are urged to follow a deep prevention approach, through upstream prevention rather than focusing on local, national, and international spread after spillover occurs (i.e. downstream prevention) (24,25). However, global as well as national and local-level institutional responses to zoonotic threats posed by wildlife trade are diverse, variously incorporating regulatory approaches such as trade standards, regulations, and bans (15,26). Understanding current regulatory frameworks governing wildlife trade is an important step for effective zoonotic spillover (see panel) prevention measures. Our scoping review focused on identifying and describing peer-reviewed research on regulatory approaches governing wild animal markets, including their wildlife supply chains.

2.4 Methods

Scoping reviews are an increasingly popular method to map and synthesize research evidence when the topic is of a complex or heterogeneous nature, such as the various regulatory frameworks governing wildlife trade, and when there is a need to

examine the range of research activity to inform next steps of the research process. Rather than critically appraising these studies and their content, this method supports our research questions that aim to identify and describe existing scientific studies dealing with regulatory frameworks. As Pham and colleagues clarify, scoping reviews aim to provide a descriptive overview of literature in a focused area, in contrast to systematic reviews whose aim is to provide a synthesis of evidence from studies assessed for risk of bias. Scoping reviews generally include a greater range of study designs and methodologies than systematic reviews focused on addressing the effectiveness of interventions (27).

This review was conducted based on the Arksey and O'Malley (28) 5 stages scoping review protocol that involves: i) identifying the research question, ii) identifying relevant studies, iii) study selection, iv) charting the data, and v) collating, summarizing and reporting results.

Identifying the Research Question

This scoping review aims to identify and describe studies focused on regulatory approaches (see panel) that govern domestic and international wildlife trade, to assess and clarify the role of national and global-level institutions in the prevention of zoonotic spillover and infection transmission between humans. The scoping review was guided by the following research questions:

- I. What are the different regulatory approaches governing national or domestic wild animal markets for human consumption, traditional medicine, and exotic pets described in the published literature?

- II. What are the different regulatory approaches governing importation of wild animals across international borders described in the published literature?
- III. What are the roles of national and global-level institutions in the prevention of local zoonotic spillover and infection transmission described in the published literature on regulatory approaches governing wild animal markets?

Identifying Relevant Studies

Literature searches to identify potentially relevant documents were carried out in OVID-Global Health, OVID-PUBMED, Web of Science, Scopus, and OVID-Embase electronic databases. The first search of these electronic databases covered publications from January 01, 2000 until June 8, 2021. A second search of these electronic databases included articles published from June 08, 2021 until August 06, 2021, and a third search of these electronic databases included articles published between August 06, 2021 until October 17, 2022.

The search strategy included the concepts of 'regulatory approaches,' 'wild animal markets, traditional medicine, and exotic pets,' 'importation,' 'international borders,' 'national and global institutions,' 'prevention,' and 'zoonotic spillover.' The full electronic search strategy and the research questions that guided the analysis of the identified articles is presented on Supplementary Material 1.

Selection of studies to be included

The study followed PRISMA scoping review guidelines to systematically identify and analyze relevant studies (32).

Eligibility criteria included articles: 1) written in English, 2) published from 2000 to 2022 to address current approaches, and 3) published as scholarly peer-reviewed literature. To be included, articles must discuss at least one of three points:

- a) Regulatory approaches governing national or domestic wild animal trade, with uses including traditional medicine, wet markets, live markets, food, or exotic pets;
- b) Regulatory approaches governing the importation of wild animals and the international wildlife supply chain;
- c) The role of local, national, and global-level institutions in regulating wild animal trade for food, traditional medicine or exotic pets.

Charting, Extracting, Analyzing and Presenting the data

Data charting followed the process described by Pham et al. (27) The data chart was iteratively developed and reviewed by RG, RA and MW, with inputs by EG to confirm relevance and to ensure quality of the data extracted. Findings were reviewed by other researchers who discussed questions, concerns, and themes from the data charting and analysis process until consensus was reached.

Variables used for data charting and analysis were deductively derived and adapted from Vrbova et al's (2010) systematic review of surveillance systems for emerging zoonoses (33). The extracted data were summarized into a table using the following variables: author(s); title/year of publication; type of publication; study objectives; study design and/or methodological approach; key results from study; conclusions (Supplementary Material 2 – Study Characteristics). We analyzed the included articles through qualitative thematic analysis, inductively grouping studies conducted on regulatory frameworks with similar characteristics, based on the three

research questions informed by the objectives of the study. Sub-themes were subsequently identified as our analysis addressed research questions, informing the identification of research gaps and recommendations for future research.

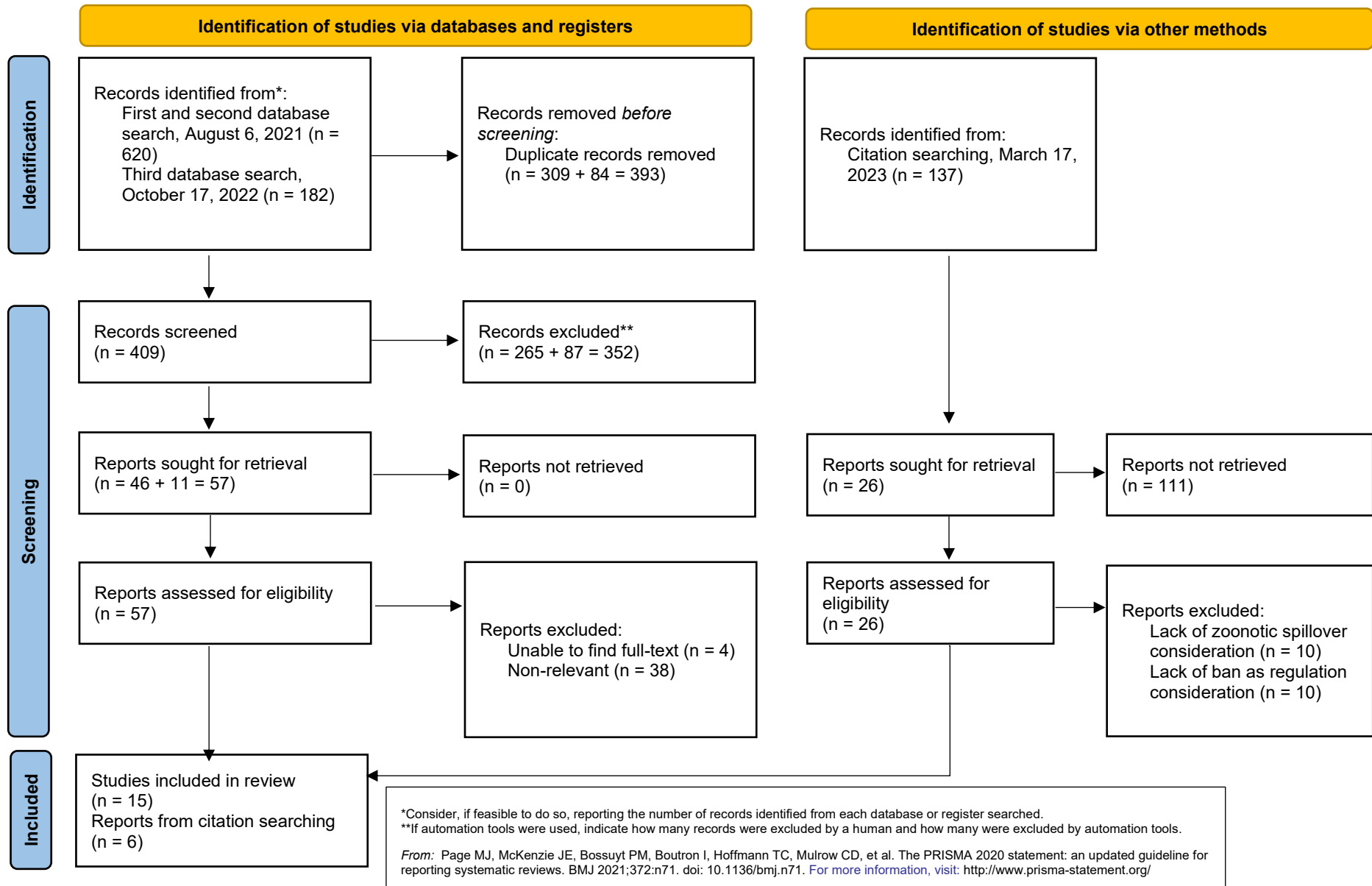
2.5. Results

Study Inclusion

The first and second database searches yielded 620 articles. Two articles were manually added to the list of relevant studies by one author based on backward citation search. Of these, 309 were excluded due to duplications. From the remaining 311 articles, 265 were excluded after screening their relevance based on title and abstract review. Forty-six articles from the first and second database search and an additional 2 articles that were manually included were retrieved for full text review for a total of 48 articles.

The third database search yielded 182 articles. Of these, 84 were excluded due to duplication. Of the remaining 98 articles, 87 were excluded after screening their relevance based on title and abstract review. 11 articles from the third database search were retrieved for full text review. A search was conducted to ensure variations of the word ban were captured, resulting in the inclusion of 6 articles in the list of selected studies. Discussions between reviewers to further exclude articles occurred after the scoping review protocol charting table was completed for a finer understanding of the relevancy of the articles. Among the 65 articles selected for full screening, 21 articles were included in the data extraction table. A PRISMA diagram illustrating how sources of evidence were selected may be found on page 10 (Figure 2.1).

Figure 2-1 PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources



General Characteristics of the Studies

The results below were organized according to the research questions. Under each section, we first present relevant regulatory frameworks, before discussing how these frameworks impact the governance of wildlife trade and what challenges they face due to lack of central authority and fragmentation of policy responses.

Regulatory approaches governing national or domestic wild animal markets for human consumption, traditional medicine, and exotic pets

Regulatory approaches governing wildlife trade

Regulatory approaches governing wildlife trade aim to strike a balance between supporting legitimate and sustainable trade for conservation purposes while preventing illegal trafficking and protecting threatened species. These approaches can differ between countries, but there are some common elements and international agreements that influence wildlife trade regulations, in particular the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). CITES is an international treaty that came into effect in 1975 and is one of the most crucial regulatory frameworks for wildlife trade. Its goal is to ensure that international trade in wild animal and plant species does not threaten their survival. However, individual countries enact their own wildlife laws and regulations to govern domestic trade and protect their native species. These laws may specify which species are protected, which are allowed for trade, and what permits or licenses are required for legal trade.

Establishing the legality of wildlife trade can be difficult. For Toland et al. (34), the distinction between legal and illegal trade between countries can be problematic, as trade considered legal or illegal in one country may be the opposite from the viewpoint

of another country's legislation. Romero-Vidal et al. (35) found that the legal export of parrots may be maintained while the domestic capture of parrots as companion pets is prohibited among neotropical countries (approx. 46 countries in Central and South America, including Mexico); or parrots as crop pests may be legally hunted while keeping parrots as pets is prohibited. In some cases, issues are also in evidence domestically: wildlife trade regulations in China were found not to function as expected given outdated protected species lists, insufficient cross-sector collaboration, and weak restrictions and law enforcement for the farming and trading of species (36).

China's 2020 decision to ban the trade and consumption of terrestrial wild animals (19) also features inconsistencies between China's Protected Species List and the extinction risks set by CITES and the International Union for Conservation of Nature (IUCN) (37), demonstrating the gap between the scientific justifiability of the ban on conservation grounds (38). This ban excluded species with zoonotic spillover potential such as bats, which raises concerns as bats are the suspected reservoir of SARS-CoV-2 and the natural reservoir for a range of coronaviruses (37), and highlights the need for research addressing the nexus between bushmeat, wet markets and disease within a One Health (OH) framework (39).

Wildlife trade also underlies traditional medicine and exotic pets. The United Nations Environment Program (UNEP) and International Livestock Research Institute (ILRI) cite global trade in traditional medicine and exotic pets as one of the reasons for the expanding human-animal-environment interface within which zoonotic spillover is facilitated (20). Toland et al. and Neuwirth et al. (34,40) argue that the regulation of

traditional medicines and exotic pets is plagued by problems of fragmentation and a lack of oversight.

Neuwirth and Svetlicini (40) highlight the patchwork nature of international law (eg, conflicts of laws) and compare this to the subdivision and specialization of international legal regimes.

One of the biggest challenges for governing wildlife trade is the fragmentation of authority and ambiguity of regulation. For Huan et al. (37), China’s 2020 Wildlife Protection Law provides ambiguous legal provisions where restricted wildlife may still be used commercially for fur, traditional medicine, and captive breeding . D’Cruze and Macdonald (2015) call for extending the ban on the Asian big cat trade to include commercial trade in captive bred individuals given the increase in illegal poaching of clouded leopard parts for traditional medicine (41). To address the fragmentation and lack of oversight in the global trade of amphibians as pets, Borzee et al. (26) recommend regulating the movement of such amphibian species that can spread pathogens through the global pet trade to prevent zoonotic spillover.

Regulatory approaches governing traditional medicine trade

Table 2-1 below summarizes information describing the international legal regimes regulating traditional medicine (40).

Table 2-1: The international legal regimes that regulate traditional medicine

Type of law	Source of governance/regulation	Purview	Degree of legal harmonization ¹
International trade law	The World Trade Organization (WTO) framework	Rules on goods and services	High
International intellectual property rules	WTO Agreement on Trade-Related Aspects of Intellectual Property Rights, and the World Intellectual Property Organization Conventions	Copyright, trademarks, and patents, intangible cultural heritage or traditional knowledge	High

Competition or anti-trust law	National and regional competition rules	Regulate unfair trade practices and methods of competition	Low
International health law	Governed by the World Health Organization (WHO)	Traditional and conventional medicine	Low
International private law	National rules on conflicts of laws	Governing the international activities between private persons	Low

¹ Legal harmonization refers to how medical and health goods are regulated (e.g. unified or fragmented regulation/legislation) and the level (e.g. national, regional, global) (40).

Regulatory approaches governing traditional medicine trade aim to address the potential impacts on wildlife conservation and animal welfare while respecting cultural practices and traditional knowledge. The trade of animal parts and derivatives for use in traditional medicine has been a significant concern due to its contribution to illegal wildlife trafficking and threats to endangered species.

Traditional medicine is increasingly dominated by western governance arrangements that regulate relations between health, trade, and intellectual property rights, and, as such, is subject to similar degrees of harmonization and fragmentation (40). CITES also plays a crucial role in regulating the international trade of animals and plants used in traditional medicine. The treaty categorizes species into different classes (Appendices I to III), with varying levels of protection, and stipulates that permits are required for the international trade of species listed under Appendix I and II, ensuring that trade is legal and sustainable. In addition, some countries maintain positive lists that identify which animal parts and products can be legally used in traditional medicine. These lists often exclude endangered species and only include species that are abundant and can be sustainably sourced.

Traditional medicine has been described by Neuwirth and Svetlicini (40) as regulated within a public health environment where the dominant Western

pharmaceutical model of health care increasingly includes the practice of traditional medicine, now categorized as “medicinal products”. The authors pose that the globalized nature of the market for medicinal products and other health-related goods converge as two distinct models of health care (i.e. a Western pharmaceutical model of health care and traditional medicine). Finally, the authors do not link traditional medicine or traditional medicines containing or being derived from animals or animal parts with zoonotic spillover, zoonotic infection transmission.

Regulatory approaches governing exotic pet trade

Legislation concerning both the trade and possession of exotic pets in the European Union, the United States, and Canada is analyzed by Toland et al. (34) who highlight the fragmentation and lack of oversight by a single authority. In addition, Toland et al. (34) linked trade in exotic pets and their ownership with zoonotic infection transmission, but not zoonotic spillover (see panel for definition), where they define zoonotic infection transmission as the incidence or end result of human infection with animal-based diseases (e.g. salmonellosis).

The CITES is also the primary instrument regulating the international trade in exotic pets (34) included in their list. The Convention identifies wildlife species that may be legally traded, in what quantities, and under which conditions (idem), whereas the Bern Convention on the Conservation of European Wildlife and Natural Habitats and the Bonn Convention on the Conservation of Migratory Species of Wild Animals strengthens the legally binding nature of provisions within CITES for states that are a party to both conventions.

At the national level, legislation regulates trade in exotic pets through implementation of the above conventions and, where applicable, further limits the human-exotic pet interface from hunting to possession or ownership (34). Such additions to international standards are permitted so long as the national standards are more stringent and scientifically justifiable (38).

Although national-level regulations are therefore compatible with the minimum required by international regulations, Toland et al. (34) argue that a lack of harmonization exists regarding which species' trade is expressly prohibited, resulting in a legal gap where some species' trade are targeted systematically, and prohibited only nationally and not internationally by CITES. This can be observed in the case of continued international trade in the Australian shingleback lizard (42) despite strict regulation of the species' trade domestically in Australia, and no international recognition of this domestic protection.

In the case of the poaching and international trade in parrots, differences in the timing of the national implementation of international wildlife legislation (i.e. CITES) varied between countries in Central America, the Caribbean, and South America, allowing protected parrot species poaching, keeping as pets, and being traded, presumably until countries ratify and implement the Convention (35).

Beyond the potential incompatibility between national and international regulations, challenges in the regulation of the exotic pet trade are similar to those identified above for wildlife and traditional medicine trade, in particular the fragmented nature of the regulatory landscape.

Regulatory approaches governing international importation of wild animals

Table 2-2 summarizes institutions, conventions and environments that govern importation of wild and domesticated animals across international borders.

Table 2-2: Institutions, conventions and environments that govern international importation of wild and domesticated animals across international borders

Institution/ Conventions	Mandate	Instrument	Impact	Effect
World Trade Organization (WTO)	Ensure free trade	Legally-binding	Sets regulations and standards related to trade generally. Provides dispute settlement for international trade.	Harmonize national regulations and standards. Provide incentives related to free trade.
Convention on the International Trade in Endangered Species of Fauna and Flora (CITES)	Wildlife species survival	Legally-binding (as per WTO Sanitary and Phytosanitary Agreement)	Set quotas for wildlife trade. CITES Appendices Significant trade review and other recommendations.	Harmonize national regulations and standards.
World Organization for Animal Health (WOAH)	Animal health and welfare	Legally-binding (as per WTO Sanitary and Phytosanitary Agreement)	Set standards for animal health and welfare. Set standards for diagnostic tests and vaccines. Evaluate and analyze national veterinary services.	Harmonize national regulations and standards.
International Union for Conservation of Nature (IUCN)	Animal movement (internationally) and animal welfare	Non-legally-binding	Provides guidelines and best practices.	Influence national regulations and standards
International Plant Protection Convention (IPPC)	Limit invasive alien species	Legally-binding (as per WTO Sanitary and Phytosanitary Agreement)	Provides standards and risk analysis guidance.	Harmonize national regulations and standards
Convention on Biological Diversity (CBD)	Limit invasive alien species; protect biodiversity	Legally-binding, yet lacks compliance measures	Provides guidelines and best practices.	Harmonize national regulations and standards.

The WTO has the overarching responsibility for regulating international trade, including trade in wildlife (38). Through the WTO's Sanitary and Phytosanitary (SPS) Agreement, certain international organizations are recognized as the reference organization regarding standard-setting related to trade. However, the WTO, through the SPS Agreement, does not ensure state compliance with the reference institution's standards, but is concerned with preventing unnecessary disruptions to trade. The SPS Agreement prevents national measures that derogate or exceed those measures of the reference body (38). That is, the reference organizations maintained in WTO and newer bilateral or regional trade agreements only have legal authority once states' measures exceed those of the reference organizations and cannot meet the various science-based thresholds. Where wildlife-related agreements and regulatory standards (e.g. CITES, Codex Alimentarius - CODEX, World Organization for Animal Health - WOA, International Plant Protection Convention – IPPC, Convention on biological diversity - CBD) are discussed in new bilateral or regional trade agreements, non-compliance by parties to these trade agreements are not subject to dispute resolution, and are thus unenforceable (43). Therefore, the extent to which reference organizations regulate the importation of wild animals across international borders is largely realized by the WTO through standard-setting based on the SPS agreement (38).

Similar to the governance of traditional medicine and exotic pets, the responsibility for importation of wild animals is spread throughout a few organizations. Based on the findings of Cooper and Rosser (38), two broad groups of institutional mandates exist for regulating the importation of wild and domesticated animals each with their own regulatory environment: wildlife survival and biodiversity protection.

Institutional mandates: wildlife species survival; animal health and welfare; animal movement.

CITES is concerned with wildlife species' survival and regulates the international wildlife trade to this end. CITES categorizes wildlife species into three appendices depending on the risk that international trade would have on the species' survival. Based on these appendices, the tradable quantities (i.e. quotas) of wildlife species and their products are determined. Each of these CITES appendices has associated permits and other requirements which must be met for international trade to be legal and non-detrimental to the species' survival (44). The appendices, their descriptions, and relevant importation requirements can be found in Table 2-3. CITES also conducts a significant trade review, which reviews Appendix II (listed species traded in significant quantities), and provides recommendations for the species listed in Appendix I (44). In keeping with the SPS agreement, states are obligated to base their relevant national measures on the standards developed by CITES.

Table 2-3: CITES Appendices (38)

Appendix	Description	Importation Requirement
I	Includes 'all species threatened with extinction which are or may be affected by trade'.	<ul style="list-style-type: none"> • Import and export permit or re-export certificate. • If introduction from the sea, certificate. • Non-detrimental finding required.
II	Includes 'all species which although not necessarily now threatened with extinction may become so unless trade in specimens of such species is subject to strict regulation'.	<ul style="list-style-type: none"> • Export permit or re-export certificate. Many countries also require an import permit.⁽¹⁾ • If introduction from the sea, certificate. • Non-detrimental finding required.
III	Includes species listed [unilaterally] by parties as being subject to regulation within their jurisdiction and for which international co-operation is needed to control trade.	<ul style="list-style-type: none"> • Certificate of origin or export certificate. • Non-detrimental finding not required.

By defining enforcement as the ability to ensure compliance, Cooper and Rosser (38) determined CITES' enforcement ability as successful due to trade sanctions that moved parties towards compliance in writing. A caveat is that compliance requirements are low, and many parties only meet CITES' basic requirements. In the case of seahorses, for example, Foster and Vincent (45) found that the CITES' significant trade reviews lack specificity and metrics for tracking compliance with Review recommendations, and are based on the precedents set by other species.

Developing guidance that ensures consistency in the implementation of CITES provisions as well as expanding legal definitions and approaches would address such compliance issues (26,46–48). Foster and Vincent (45) recommend 1) the focus of the CITES Review be shifted from outputs to outcomes and impacts; 2) match CITES Review recommendations to the needs and capacities of the Parties; 3) give experts a formalized role in the CITES Review process; and 4) create funding mechanisms for the Review process, the integration of experts in the Review process, and for assisting Parties in addressing the recommendations from the Review. However, Thiermann (49) argues that global commitment and political will are needed to address compliance issues rather than additional science-based international standards or improved dispute resolution mechanisms.

The WTO recognizes WOAAH (formerly OIE) as the reference organization for zoonoses and terrestrial and aquatic animal health in international trade (38). The WOAAH sets animal and aquatic animal health international trade standards for wildlife products towards ensuring animal health and welfare. While WOAAH is explicitly concerned with zoonoses, the focus is more on controlling re-emerging events and

surveillance rather than preventing the spillover of new or emerging zoonotic pathogens from being transmitted (49). The various WOH documents, their descriptions and relevance can be found in Table 2-4. In keeping with the SPS agreement, states are obligated to base their relevant national measures on the standards developed by WOH.

Table 2-4: WOH regulations, standards, and evaluation for international wildlife trade (38,50)

Document	Description	Relevance
International [Terrestrial] Animal Health Code and Manual	Outlines standards regarding the prevention of specific animal disease transmission, including laboratory operation, diagnostic procedures, and production sectors	Applies to mammals, birds, and bees Eg, veterinary certification
International Aquatic Animal Health Code and Manual	Outlines standards regarding the prevention of specific animal diseases transmission, including laboratory operation, diagnostic procedures, and production sectors.	Applies to fish, molluscs, and crustaceans farmed or released
Manual of Standards for Diagnostic Tests and Vaccines	Outlines the guidelines for the standardization and quality control of diagnostic tests and vaccines related to wildlife.	Applies to wildlife
Performance of Veterinary Services Evaluation and Gap Analysis Tools	Evaluate, analyze, and enhance the national performance of veterinary services to control animal diseases and zoonoses.	Application and submission to the tool is voluntary, i.e. non-legally binding.

Finally, IUCN (formerly World Conservation Union) regulates the international wildlife trade through the provision of guidelines and best practices related to the movement and welfare of animals (38). However, the IUCN's guidelines are non-legally binding, and thus, the implementation of and compliance with such standards are less likely than with instruments that provide economic or reputational repercussions for non-

compliance. Cooper and Rosser(38) list the following documents as the relevant guidelines and best practices of the IUCN:

1. IUCN Guidelines for the Prevention of Biodiversity loss caused by Alien Invasive Species
2. IUCN/Species Survival Commission Guidelines for Re-introductions
3. IUCN Guidelines for the Placement of Confiscated Animals Closely related to CITES Resolution Conf. 10.7: Disposal of confiscated live specimens of species
4. IUCN Policy Statement on State gift of animals
5. IUCN Position Statement on Translocations of living organisms: introductions, re-introductions, and re-stocking
6. IUCN Policy Statement on Captive Breeding

Institutional mandate: limit harmful introduction of invasive alien species

While plant pathogens have been widely overlooked in discussions about global disease spread, Kim et al. highlight instances of illness in humans caused by various bacterial phytopathogens, and the potential for opportunistic pathogens to develop infection strategies of spillover across kingdoms, challenging the notion that plant pathogens are not causative agents of disease in humans and animals (51). This led Kim et al. to consider the trade in plants and to include the IPPC in their analysis.

The IPPC regulates the international wildlife trade by developing standards to prevent the introduction, spread, and establishment of plants that could become pests (52). Such standards may be found in the *International Standards for Phytosanitary Measures*, which also include glossaries and risk analysis guidance (52). While the Convention is only legally binding for those states who choose to be a party to the

Convention, WTO parties must base their national measures on the standards developed within the Convention as per the WTO SPS Agreement (38). The IPPC is recognized by the WTO as the reference organization for phytosanitary standard-setting related to trade (52).

With regard to the prevention of zoonotic spillover to infection transmission between humans, Zhang et al. and Chinchio et al. (53,54) highlight potential for zoonoses from introduced alien species. In order to effectively prevent invasion risks and indirectly prevent zoonotic spillover, Reino et al. argue that global bans are needed as opposed to current regional bans such as those in the European Union (55). Towards limiting the harmful introduction of invasive alien species, the IPPC cooperates with the CBD. The CBD encourages state parties to regulate the international movement of genetic material to both limit invasive alien species (IAS) and to protect biodiversity, thereby affecting the regulation of the international wildlife trade (38). While legally binding, the Convention has taken a 'soft' approach toward implementation, developing instruments that are not backed by legal obligations to implement (56). Both the IPPC and the CBD do not directly address the prevention of zoonotic disease, although their respective mandates are part of the trade standards, regulations and incentives that govern the international wildlife trade.

Role of national and global institutions in the prevention of zoonotic infection within regulatory environments

The findings below emerged from the broader groups of institutional mandates found in the previous section. We assess the roles of institutions in preventing zoonotic

spillover transmission by considering how their mandates are being fulfilled. By setting international standards to guide national practice, these institutions largely inform local governance concerning the prevention of zoonotic infection.

Overall, the findings indicate that a mandate to prevent zoonotic spillover was not always explicitly the focus of institutions and their respective regulatory systems. While such regulation would contribute to zoonotic spillover prevention, it would do so indirectly and through other pathways (e.g. by promoting animal health).

Indirect prevention of zoonotic spillover; prevention of infection transmission between humans (WOAH, FAO, WHO)

The United Nations Food and Agriculture Organization (FAO), WHO and WOAH engage directly in the prevention of zoonotic infection transmission through tools aimed at surveillance, prevention and containment. The Global Early Warning System for Animal Disease is a surveillance system that tracks animal diseases and zoonoses as a joint WOAH/FAO/WHO initiative (57). Through the International Health Regulations (IHR), the WHO provides a legally binding instrument for state parties to notify, assess, and contain public health emergencies of international concern (PHEIC) (48). While the IHR do not expressly mention zoonotic disease, the scope of what constitutes a PHEIC is broad so as to cover any incident involving the international spread of diseases requiring a coordinated international response, including zoonotic spillover and resulting infections (48).

Regulation of the movement (trade) of wildlife (CITES, CBD)

Institutions may prevent zoonotic infection transmission through their role in regulating the international movement of flora and fauna. CITES regulates the

international wildlife trade through its three appendices (see table 2-3) that separate wildlife species according to the requirements of import, export, and re-export needed to ensure the survival of the species while being traded internationally (46). Although CITES has no mandate over zoonoses, by regulating the trade and movement of wildlife, CITES influences many of the factors that may lead to zoonotic spillover, such as animal welfare and biological diversity (29). The CBD regulates the international movement of genetic material towards protecting the biological diversity of countries through the similarly named Convention (38). In parallel, the IPPC controls and prevents the international spread of pests (invasive alien species) and diseases of plants (52).

Harmonization of state practice with international standards, policies and practices (WOAH, CITES, WTO, WHO, IUCN, IPCC)

Institutions prevent zoonotic infection transmission through their role in setting international standards, which may guide the legislation and practice of state parties and non-governmental organizations. The WOAH sets international trade standards (trade quotas) through the Terrestrial Animal Health Code and the Aquatic Animal Health Code (38). Similarly, the CITES provides legally-binding requirements for the international trade of wildlife within the CITES appendices, as mentioned in the earlier section dealing with the regulatory environment governing the import of wild and domesticated animals. State parties are legally obligated to consult and base their practices and legislation on the respective WOAH and CITES guidelines, depending on the commodity being traded and the animal disease(s) of concern (38). IUCN provides guidelines on aspects related to the movement and welfare of wildlife within

international wildlife trade (38). However, these guidelines are at the discretion of states to consider and are non-legally binding and non-enforceable.

The IPPC sets standards related to the environment and biodiversity to help state parties harmonize their management of invasive alien species related to plants (52). In this way, the role of the IPPC transitions from the standard setting role of institutions such as the WOAAH and the CITES Secretariat to the harmonizing and coordinating roles of the WTO and the Codex Alimentarius Commission.

The WTO enforces the harmonization of national measures with international animal health laws and trade rules by providing dispute settlement for trade disputes between state parties (38). The Codex Alimentarius Commission promotes the coordination of the food standards undertaken by international governmental and non-governmental organizations (52). The WHO's IHR may be viewed as international standards regarding disease surveillance, notification and control that direct state action given their legally binding nature (48).

Information sharing and disease control capacity building (WOAH, CITES)

Institutions prevent zoonotic spillover and infection transmission between humans through their role in facilitating capacity building for states, especially concerning disease prevention surveillance and control efforts. The WOAAH facilitates capacity building for states, especially in mainstreaming veterinary services and veterinary public health as a key part of the national and international response to the international wildlife trade and animal disease prevention and control, as well as information sharing amongst state parties regarding expertise and best practices (57). Similarly, WOAAH certifies the competence and credibility of national veterinary services

through the Tool for Evaluation of Performance of Veterinary Services (WOAH-PVS Tool) and facilitates capacity building in national veterinary services to promote trust amongst international trading partners and ensure the international wildlife trade fosters public and animal health (57). TRAFFIC, the Wildlife Trade Monitoring Network, acts as a source and facilitator of research and data regarding the trade status of, and threats to CITES species; reports of prosecutions for illegal trade; and CITES enforcement activities globally (38).

2.6. Discussion

This scoping review aimed to identify and describe studies dealing with regulatory approaches governing wildlife trade to assess the role of national and global level institutions in the prevention of zoonotic spillover and infection transmission between humans. Findings addressing the three research questions are discussed below.

Regulatory environment governing national or domestic wild animal markets for human consumption, traditional medicine and exotic pets

Our review on regulations governing wildlife trade found evidence of temporal mismatch between countries adopting CITES protected species lists, and of partial mismatch between the protected species list developed by CITES and domestic lists (19,36,37). Future research on countries facing similar issues could focus on assessing the effectiveness of precautionary interim risk management approaches that adopt updated CITES lists, while domestic lists are updated and legislation is ratified and implemented.

Within the environment governing traditional medicine, the WTO is the main regulatory organization, providing the basis for two of the identified five regimes: international trade law and international intellectual property rules. These trade law and intellectual property systems also reflect a high degree of international legal harmonization, granting the WTO recognized authority on international trade as Cooper and Rosser emphasize (38). However, a focus on the primacy of the WTO in regulating traditional medicine would neglect the role of the WHO and international health law. While the dynamics of health and trade as two distinct approaches are considered within the broader literature on health and trade (58,59), the complex regulatory environment described in our findings – and broader intersectoral OH linkages between wildlife trade and complex socio-ecological interactions that produce the vulnerable interfaces where zoonotic spillover occurs - tend to be oversimplified (60).

The same applies to the dynamics of conservation and the risks posed by animal trade for traditional medicine purposes, especially given the renewed interest in regulating wildlife trade due to the global SARS-CoV-2 pandemic, which likely reflects a similar zoonotic spillover process that led to the SARS pandemic (15,61). However, trade and health and trade and conservation, as competing interests, demonstrate the patchwork nature of regulation in traditional medicines and exotic pets.

Organizations and regulations emerging to address regulatory gaps designed to strengthen extant regulations and standards face challenges harmonizing arrangements that reflect different institutional mandates and jurisdictional priorities. This is evident in the exotic pet regulation with the Bern Convention on the Conservation of European Wildlife and Natural Habitats and the Bonn Convention on the Conservation of Migratory

Species of Wild Animals strengthening CITES provisions, where trade of certain species might be legal at the national level, but illegal at the international level (34).

It may, however, be argued that international trade law, international intellectual property rules, and competition or anti-trust law may be combined, given that these different foci relate to trade (62). More generally, no singular supranational agency exists to coordinate amongst these identified legal regimes to regulate traditional medicine. In the case of exotic pet regulation, it may be argued that compliance and enforcement challenges are responsible for such legal pluralism (63).

While animal products are used in traditional Chinese medicine and the practice of this form of medicine has been increasing in recent years (64), our results support the general finding that the role of animals and animal products in traditional medicine is neglected (65) or not systematically studied (66) in the literature.

Neuwirth and Svetlicini (40) use the term Traditional Chinese Medicine to operationalize what they term “traditional Oriental medicine”, thereby obscuring differences in the culture, history, knowledge, and context between different countries and their Indigenous peoples, including Malaysia, Singapore, Australia and Hong Kong. This reflects the lack of clear distinction between these various forms of medicines, perhaps promulgated by the current international regulation of traditional medicine. Neuwirth and Svetlicini(40) found traditional medicine was broad enough so as to include traditional Chinese medicine as a subset within traditional medicine, and more so to regulate medical products and treatments generally.

The partial coordination of exotic pet regulation at the national/sub-national and international levels as found by Toland et al. (34) may also suggest lack of research

considering ecosystems within a OH approach (67,68). Future research on trade in exotic animals and pets from a OH and biodiversity lens may be useful to inform future regulatory approaches governing this dimension of wildlife trade.

Regulatory environments governing importation of wild and domesticated animals across international borders for food

In considering the prevention of zoonotic spillover, the literature identified suggests gaps related to incomplete institutional purviews and a lack of express mandates for preventing zoonotic spillover. Reeve (44) notes that CITES does not address the markets where wildlife is sold, nor provides for the prevention of zoonoses. Similarly, Khan and Pelgrim (52) note that the WOAHA mandate does not expressly consider the control of invasive alien species or the protection of biodiversity, despite a broad purview. Where WOAHA contributes to these ends, Khan and Pelgrim (52) note that it is through an animal health perspective. Alternatively, the IPPC's purview is also relatively limited given its focus on plants.

The purviews of WOAHA and IPPC complement each other in a patchwork manner, as organizations emerge to address the gaps in the current regulatory environment. The effects of incomplete institutional purviews also explain issues related to enforcement of, and compliance with international standards, regulations and incentives.

National CITES-implementing laws do not cover all wildlife species but only those within the CITES appendices, and the liability for violating such national legislation is not tailored to the specifics of the violation (e.g. types of offenders and their resources, the circumstances and level of involvement of the offender), nor coordinated internationally

(44). This lack of coordination may also hinder the effectiveness of national and international wildlife trade bans aiming to prevent zoonotic spillover.

Similarly, Wingard et al. (48) note that WOAHA Listed Diseases include only those that are established as relevant to wildlife and international trade (i.e. of economic utility). That is, the reporting of non-WOAH listed diseases is voluntary, and new and emerging infectious diseases are not expressly considered. What the regulatory frameworks lack is the capacity to prevent those new pathogens from emerging in the first place (24). Further research considering the impact of incomplete or fragmented regulatory purviews on wild and domesticated animal importation and zoonotic spillover may be useful to inform enhanced governance approaches to prevent zoonotic spillover events.

Role of national- and global- level institutional coordination in preventing zoonotic infection

Despite a common set of institutional roles in the prevention of zoonotic spillover and transmission, organizations had differing degrees of influence and agency with respect to a given role. Organizations such as FAO, WHO and WOAHA engage in preventative, surveillance, and containment measures, while the CITES considers import/export requirements to protect species survival. These findings support the results of an analysis of legal instruments related to animals relevant to zoonoses conducted by Viens et al. (69). Their analysis reveals fragmentation in the underlying conceptualization of how animals are viewed and treated, which is problematic for effective collective action and coordinative governance designed to prevent pandemic zoonoses. As the authors found, “*The international legal instruments that these*

governance systems use reflect different ways of viewing and treating animals, which has led to a similarly fragmented approach to the regulation of human–animal interactions related to zoonoses” (69). Information-sharing and capacity building are also important aspects of zoonotic prevention efforts, and future research could explore the extent to which information sharing mechanisms among global and national level organizations support the harmonization of wildlife trade regulations preventing zoonotic infection.

We found no evidence of formal logic in how these roles were divided between national and global organizations. Organizations had mandates to fulfill the regulatory gaps that emerge within the broader environment (i.e. its constituent organizations and treaties), particularly after a critical juncture that would fundamentally alter society, such as the global SARS-CoV-2 pandemic. Given such a patchwork design, confusion and lack of coordination would result. Future research could mobilize a OH approach to improve information sharing and intersectoral governance and policy coordination that contributes to a better understanding of the role of global and national organizations in preventing zoonotic spillover and transmission.

2.7 Conclusion

Reducing the probability of spillover events is key to prevent future pandemics. Regulatory measures involve reducing the human footprint in natural systems – including but not limited to wildlife trade (70,71) - and emphasizing the inclusion and separate funding of regulations and measures that address ecology, conservation, and wildlife biology related to spillover prevention in multilateral cooperation fora (70,72,73). Spillover prevention measures also involve the adoption of varying degrees of wildlife

trade bans (22,74). Such recommendations consider the trade-offs in livelihoods and food security to protect global biodiversity and significantly reduce the risk of zoonotic spillover and transmission (21).

Our review found instances where the institutional and regulatory purview of zoonotic spillover prevention in the wildlife trade is characterized by fragmentation and lack of oversight by a single coordination authority. The lack of harmonization within and between national and supranational regulations reflect competing interests and organizational mandates across jurisdictions and sectors. Effective policy responses must take the differing relative zoonotic spillover risks in wet markets, live-animal markets, and wildlife markets into account.

Enhanced coordination and collaboration for prevention of zoonotic infection and spillover and infection transmission may be informed by future research focusing on the effectiveness of timely information sharing and global- and national- level harmonization of wildlife trade regulations.

List of abbreviations

CBD	Convention on biological diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CODEX	Codex Alimentarius
FAO	United Nations Food and Agriculture Organization
IHR	International Health Regulations
ILRI	International Livestock Research Institute
IPPC	International Plant Protection Convention
IUCN	International Union for Conservation of Nature
OH	One Health
PHEIC	Public Health Emergencies of International Concern
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta
SPS	Sanitary and Phytosanitary
SR	Scoping Review
TRAFFIC	Wildlife Trade Monitoring Network
UNEP	United Nations Environment Program
WHO	World Health Organization
WOAH	World Organization for Animal Health
WTO	World Trade Organization

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

Data analysed during the study can be found in the manuscript. Supplementary Material 1 contains the search strategy, and Supplementary Material 2 contains a summary of the study characteristics

Competing interests

Authors disclose that they have no competing interests

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Chapter 3 – The Urban Political Ecology of Antimicrobial Resistance: a critical lens on integrative governance

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3.1 Preface

Relation between texts

Antimicrobial resistance (AMR) and wildlife trade are global health threats at the human-animal-environmental interface whose governance and regulatory environments share similar fragmentation challenges necessitating the mobilization of intersectoral approaches such as the OH approach. Bridging the epistemological domains of Urban Political Ecology and OH, this manuscript reveals under-exposed dimensions of AMR and other interconnected global health threats. Both manuscripts share an emphasis on regulatory or governance limitations, institutional coordination, the importance of interdisciplinary approaches and the importance of integrated and collaborative approaches to safeguard human-animal-environmental health. The following manuscript provides a theoretical foundation and highlights the need for research addressing One health threats through a critical urban lens.

Contribution of Authors

RA conceived the idea and wrote the first manuscript draft. MW and RK substantially revised the manuscript, providing valuable methodological and subject-matter expertise. All authors have read and approved the final manuscript.

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3.2 Abstract

The objective of this paper is to integrate Urban Political Ecology (UPE) as a theory for identifying under-exposed urban dimensions of Antimicrobial Resistance (AMR). A UPE lens allows us to conceptualize urbanization as a ubiquitous socioecological process and an interpretive frame that could inform AMR governance strategies across related contexts by: a) situating AMR risks in relation to urbanization processes shaping social and political co-determinants of such systemic threats as climate change; b) aligning UPE scholarship with One Health (OH) approaches that address AMR to reveal the under-exposed link of AMR to environmental threats and broader structural dimensions that influence these threats; and c) identifying shared AMR and environmental governance pathways that inform the rationale for more equitable governance arrangements. We delineate a context in which the speed and scale of human activity in the larger context of urbanization, driven by global market integration strategies, impacts human-animal-environmental health threats such as AMR. We demonstrate how UPE scholarship can be leveraged to offer theoretical depth to approaches considering the interdependencies of AMR and climate change threats. We then propose a strategic approach focused on identifying shared governance pathways and intersectoral accountability frameworks to address upstream structural drivers of AM-Environmental threats. The co-benefits of a UPE-informed framework to human-animal-environmental health that leverages enabling policy environments to foster a more collaborative, equitable and sustainable approach to address systemic global health threats are clarified. Just as the concept of "health in all policies" emphasized taking health implications into account in all public policy development, the integration of UPE

in AMR governance arrangements would emphasize the need to take other sectors into account through an intersectoral whole-of-government approach that fosters shared AMR - climate change governance pathways.

Keywords: urban political ecology, one health, antimicrobial resistance, global health governance, climate change, environmental threats

3.3 Introduction

Complex interdependencies among natural disasters (1), conflicts (2) and structural inequities (3) have become more evident in recent years (4). These interdependencies exacerbate global health inequities as – under their cascading impacts – governments and national health systems are often unable to adapt to and address sustained levels of fragility, instability and insecurity (5,6). The compounding effects of these systemic and intertwined global health threats also induce forced migration (7), pandemic diseases (8,9), and antimicrobial resistance (10–12). Interconnected at the global scale by accelerating patterns of human activity (13) - of which urbanization (14) can be considered one of its most pervasive forms and processes (15–20) - these global health threats impact human-animal-environmental health systems (21), putting new populations and the systems in which these threats manifest at increased systemic risk (13,22,23).

The objective of this manuscript is to propose the integration of Urban Political Ecology (UPE) as a theoretical framework for assessing under-exposed urban dimensions of Antimicrobial Resistance (AMR) within governance strategies. First, by aligning UPE scholarship with One Health (OH), we bridge two epistemic domains, offering theoretical depth that clarifies the sociopolitical ecologies of AMR and its interdependence with other OH threats (24). Second, drawing on UPE as a multifaceted approach and a guide to practical politics of sustainability and human-nature relationships, we mobilize UPE to inform governance strategies addressing the upstream structural drivers of AMR and interconnected environmental threats.

We begin by introducing a theoretical framework to assess the urban political ecologies of AMR, and advance a notion of planetary and extended urbanization processes and forms, to delineate a context in which the speed and scale of human activity driven by global market integration impacts human-animal-environmental health threats such as AMR. We trace the interconnection of AMR to other threats through urbanization and accelerated transformation processes, which are obscured by notions of urbanization that disregard the detrimental impact of these transformations on structural determinants influencing human-animal-ecosystem health (25,26). We then propose UPE as an alternative lens to explore the impact of urbanization for AMR. A UPE lens is premised on more equitable and just societal relations with nature, that situates the impact of these accelerated transformations into sociopolitical ecologies, which is imperative when exploring threats impacting human and non-human dimensions. A UPE lens allows us to mobilize the urban dimension as a ubiquitous spatial scale and interpretive frame to inform approaches addressing interdependent global health threats such as AMR and climate change. We adapt theoretical frameworks from Brenner and Ghosh (27), Ali et al. (25), and Treffers et al. (28) to explore similar connections between urbanization and political ecologies of disease to illustrate how UPEs of AMR clarify the influence of structural dimensions on sociopolitical ecologies as drivers of AMR and related threats.

We first highlight the need for a critical urban lens to advance OH approaches addressing AMR. As AMR is a natural mechanism accelerated by antimicrobial use and anthropogenic activities affecting microbial organisms, it is deeply interconnected with anthropogenic pressures on planetary health systems, the fabric of our society, current

modes of care, production and consumption, and to pathways exacerbating other global health threats such as climate change. We then discuss how efforts to address AMR are contingent on an assessment of urbanization processes that enable the commodification of health determinants and the privatization of commons resources management, referred to as the structural dimensions of AMR, that connect the OH approach to UPE theory.

We then engage UPE scholarship to demonstrate the way in which it offers a theoretical foundation that aligns with and underpins the United Nations Environmental Program approach and guidance for addressing the interdependence between AMR and climate change (29). Two tenets of UPE scholarship are introduced to structure the way in which UPE can inform AMR governance strategies: rescaling socioecological governance arrangements and redressing human-animal-environmental relations.

We propose that *rescaling socioecological governance approaches* through a UPE lens informs strategies that seek to address AMR externalities. We also posit that rescaling via whole-of-government and whole-of-society approaches (30) would enable One Health shared governance to advance action on climate change while “...*addressing the collective need for clean water, energy and air, safe and nutritious food...*” as the joint Tripartite and UNEP statement advises (31).

A UPE lens also informs OH approaches to AMR concerned with *redressing human-animal-environmental relations* by considering the health inequities and environmental injustices accelerating AMR, that go beyond current approaches premised on the logic of biomedical security, surveillance, and behavioral change. Insights into human-animal-environmental relations also consider how different

urbanization processes influence the health and environmental dimensions shaping AMR risks, and how urbanization forms linked to these processes have been regarded AMR hotspots (32). Such insights offer new entry points to explore how extended urbanization processes intensify AMR risks. The theoretical insights then inform a strategic approach focused on identifying shared AM-Environmental governance pathways to address these related threats. We examine environmental stewardship literature to suggest the adoption of shared governance pathways and intersectoral accountability frameworks that simultaneously address AMR threats, their structural dimensions and interdependencies with other threats. The co-benefits of shared governance pathways and intersectoral accountability frameworks to human-animal-environmental health are highlighted as a UPE-informed framework relying on enabling policy environments to foster a more collaborative, equitable and sustainable approach to address systemic global health threats.

An urban dimension thus informs OH approaches designed to address the global health threat of AMR by *adjusting its drivers*. Although an in-depth and systematic engagement with UPE literature is beyond the scope of this paper, we engage key works to generate synergies across disciplines, reveal and address gaps in the literature by juxtaposing articles summarizing main contributions of UPE scholarship (27,30) with those focused on the theory and practice of AMR governance.

3.4 Unsettling traditional urban conceptions towards more productive urbanization approaches in global health

Globalized urbanization (3,14), in conjunction with rapid technological change (33–35) has accelerated the transformation of social, health, political, economic and

environmental dimensions and relationships (8,34,36–40). At structural levels, these transformations lead to an acceleration in the time needed to produce and sell commodities to generate quicker accumulation of profits for firms and investors, and to restructure or privatize previously public institutions and public goods, including provisions for healthcare and education. In turn, these transformations result in processes which intensify the exploitation of human beings and nature for purposes of extraction and profit, leading to the dispossession of communities of their basic and local means of subsistence and livelihood, with land often at the centre of concerns (41,42). Driven by the pervasive financialization of economic relationships in all sectors (18,43,44), many of these transformations are obscured by the mobilization of generic notions of urbanization commonly cited as an inherent dimension of human development (45,46).

These same accelerating patterns that transform societies and open new frontiers of production and consumption possibilities also appear to widen local and structural health inequities (15,17,47). Much like the transition to industrial societies where large-scale manufacturing created instability and restructured the previous agrarian order through various forms of commodification (48,49), recent patterns of accelerated human activity also create instability, replace the social and economic foundation of pre-existing systems, accelerate the negative impacts of the Anthropocene (50), and restructure the distribution of resources globally (3,47,51). The current restructuring facilitates new forms of commodification of health determinants such as housing, food security and education (52), and facilitates the privatization of commons resource management such as water, land and natural resources (53). It is

against this backdrop that One Health approaches aim to address the collective need for clean water, energy and air, taking action on climate change to promote human-animal-ecosystem health and well-being (54,55).

The commodification and privatization of structural dimensions sustaining planetary health are thus accelerated by shifts in the scale of human activity advanced by traditional urbanization approaches promoting visions of smart cities in the global south (56), or a combination of technological innovation, economic development and world-class leadership in “super-cluster” initiatives in the global north (57). Considered an essential step in state economic development, these approaches postulate that successful high-income societies depend on efficient economies with urban connectivity and infrastructure, that enable networks of communication and productivity, that in turn accelerate consumption patterns (37,58). The scale of these shifts has been measured in terms of economic growth and the developmental imperative to move economies from low to high productivity (58). Traditional urbanization approaches thus enable the acceleration and increase the scale of human activity by rescaling the nature of economic relations (59). In doing so, they also rescale societal relations and shape human behaviors according to global market integration strategies, which has been shown to exacerbate inequalities and systemic threats to global health (17).

Current notions of urbanization may therefore mask the detrimental impact of these accelerated transformations on health determinants and commons resources (25,26), calling for approaches that can problematize their influence on structural dimensions and global health threats (60).

An urban political ecology lens (UPE) can develop new ways of understanding global health threats such as AMR in these complex and interdependent systems. UPE conceives human and more-than-human relations with nature as non-linear and mutually constitutive processes of urbanization (15,30), as these contend with climate change and environmental degradation in a predominantly urbanized world. UPE provides the conceptual tools to examine how societal relations with nature shape the conditions and produce the vulnerabilities that enable the acceleration of AMR (61,62). Through a UPE lens we can situate these accelerated transformations within more productive sociopolitical ecologies that are premised on equitable and just societal relations with nature (30).

By mobilizing a UPE lens to explore mechanisms underlying the intensification of microbial traffic and the production of infectious diseases, Brenner and Ghosh (27) propose a theoretical framework to situate political ecologies of infectious disease within planetary urbanization processes operating at a global scale. They succinctly describe planetary urbanization processes as an *“intensification of city-building processes... and the remaking of territories and political ecologies beyond metropolitan centers, whether in zones of high-intensity agro-industrial and extractive capitalism, or in more remote hinterlands, forests, and oceans that are being more directly subsumed into global circuits of capital...”*

We also adapted the approach of Ali et al. (25) and Treffers et al. (28) to consider AMR as not only determined by biophysical processes, but also constructed out of a particular set of social and spatial relations that are mediated through the landscape, including extended urbanization forms. As research on governance of AMR strategies is

concerned with the influence of similar global governance and market forces, and hierarchies of economies from the Global North (16,63–68), our framework exploring UPEs of AMR conceives similar global forces and hierarchies as urbanization processes that influence the local production of AMR. Specifically, UPEs of AMR would consider the impact of planetary and extended urbanization processes on health determinants and commons resources, as these structural determinants influence local socioeconomic demand and sociopolitical ecologies producing vulnerabilities accelerating AMR (55). While UPE-informed research on AMR responses that consider the impact of urbanization processes, structural determinants, or global governance and economic forces are largely nonexistent, research identifying AMR hotspots subject to socioeconomic demands and sociopolitical ecologies include: marine, freshwater and terrestrial ecosystems, wastewater treatment infrastructures, agricultural sites, aquaculture operations, hospitals, and urban settlements (32,69–73).

In a world increasingly interconnected by urbanization processes and forms that profoundly rescale human-nature relations and the subsequent unequal global distribution of resources (3,74), addressing emerging and interdependent global health threats under these conditions demands an analytic framework that falls outside traditional global health governance (23,36,75–78). AMR, pandemics, biodiversity loss and climate change are examples of threats which require effective mobilization of shared governance approaches that consider the interdependencies at multiple scales, topographies and through constellations of agencies (79). Although these threats pose similar risks to human-animal-planetary health, institutional responses jointly addressing them have only recently been proposed (80), but not yet fully implemented (29,81–84).

The UN Quadripartite, a group of UN agencies collaborating to address global health threats such as AMR, publishes guidance documents supporting the integration of environmental dimensions alongside human and animal health measures addressing AMR and its interdependencies. The UN Environment Program (UNEP) recommends the integration of environmental considerations into National Action Plans on AMR, and AMR into environmental-related plans such as national chemical pollution, waste management programmes, biodiversity and climate change planning (29). Exploration of UPEs of AMR can thus offer theoretical depth to inform shared governance approaches, by informing AMR responses that consider local and structural determinants and similar interdependent threats addressed in broader commitments to climate change (for example), potentially enhancing shared governance approaches jointly addressing AMR and related threats (85).

3.5 Towards a critical urban dimension of AMR and One Health

Increasing evidence shows that AMR can be intensified by other existential threats such as pandemics, climate change, and biodiversity degradation (86–88). A recent review revealed significant research gaps linking AMR and climate change, synthesizing evidence of shared processes exacerbating both threats (89). Examples linking AMR and climate change look at the effect of the climate crisis impacting concentrations of heavy metals or biocide in soil and water, which are also associated with increased bacterial growth rates and horizontal transfer of resistant genes. Rising temperatures, flooding and the resulting heightened population densities and population displacement also lead to increased waterborne infections and added pressure on healthcare and water, sanitation and hygiene (WASH) systems, increasing risk of

infection by antibiotic-resistant pathogens (see table 1 for a summary of the relationship between climate change and AMR).

Table 3-1. Impact of climate change on microbial lifecycles

Microorganisms	Role of Climate Change	Disease
<i>Campylobacter</i> spp. and <i>Salmonella</i> spp.	Rising temperatures in water system contributes to better survival of these microorganisms [31,58,59,82]	Waterborne and foodborne diseases
<i>Vibrio cholerae</i>	Rising temperatures led to natural disasters, determining better conditions for the microorganism survival [59,116]	Waterborne diseases (Cholera)
<i>Candida auris</i>	Gained thermotolerance and salinity tolerance on the wetland ecosystem [31,76,77]	Fungal infection (Candidiasis)
<i>Plasmodium falciparum</i>	Rising temperatures and humidity contributes to increased transmissibility [56,78,80]	Vector-borne disease (Malaria)
Zika, Chikungunya and Dengue viruses, <i>Trypanosoma cruzi</i>	Warmer temperatures led to rising spread of vectors, even in winter months [83]	Vector-borne diseases (Zika, Chikungunya, Dengue and Chagas diseases)
<i>Pseudomonas aeruginosa</i> , <i>Klebsiella pneumoniae</i> , <i>Escherichia coli</i> , and <i>Staphylococcus aureus</i>	Warm-season changes in temperature contributes to their optimal growth conditions at 32–36 °C [101]	Gram negative infections (especially in healthcare settings)
SARS-CoV-2	Increased aridity and prolonged droughts led to bats migration and increased viral transmission [32,33]	COVID-19 disease

Source: San Lio et al, 2023 (89)

Despite knowledge gaps underlying causal relationships relating AMR and climate change to anthropogenic activities and other interconnected health threats, policymakers already seek to adopt approaches and measures addressing the interdependencies of AMR (81–83,90).

The One Health approach has been increasingly adopted in academia, by the public sector and international organizations seeking to address similar global health challenges. In 2022 members of the Quadripartite (FAO, WHO, WOAHA and UNEP) released a joint statement supporting a more transdisciplinary and holistic operational definition of One Health (31), as:

“an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent. The approach mobilizes multiple sectors, disciplines and communities at varying levels of society to work together to foster

well-being and tackle threats to health and ecosystems, while addressing the collective need for clean water, energy and air, safe and nutritious food, taking action on climate change, and contributing to sustainable development.”

Contributions to AMR research are key to understanding the structural and socioeconomic dimensions of AMR and its implications for OH responses, including research considering antimicrobials as a common good that characterizes AMR as a “tragedy of the commons” (91–93), highlighting the importance of global collective action to address antimicrobial use (AMU). This perspective aligns with OH definitions emphasizing action to address collective needs and human-animal-ecosystem health, and a UPE lens that problematizes the structural dimensions of human-animal-ecosystem health and their influence on AMR risks. Increasing evidence also links AMR to poor governance, deficient urban infrastructure, and the current dynamics of modern society (11,70,94–97). In an urban context of social and health inequality, Chandler emphasizes higher AMR risks in urban informal settlements, and how antibiotics are a quick fix to protect against economic, political and social marginalisation. Situating AMR risks within broader political economy and structural factors influencing pathogen exposure and the embodiment of urban informality, Chandler points to the lack of AMR studies bringing urban planning into conversation with public health policy (72).

Similar contributions focusing on forms of urbanization similarly adopt a more holistic approach, calling for more equitable and environmentally just urban infrastructure to address urban health threats. A Lancet Commission on water, sanitation, and hygiene (WASH) suggests that improved WASH systems in low and middle income countries (and high income countries, vis a vis persistent colonial legacies) are a pathway to social and environmental justice efforts to address climate

change and AMR (98). How, then, can a UPE lens inform public and global health policy, given its potential to problematize AMR in relation to its structural drivers and local socioeconomic determinants of these policies?

Urbanization has long been established as playing a key role in health equity, environmental justice (4,15,70,71,99–105) and AMR (11,70). In this sense, cities have historically been considered breeding grounds of infectious disease. One reason is that increased migration to urban areas has not always been met with the commensurate scale of infrastructure and public health measures needed to sustain the health and living conditions of their inhabitants (106). Strikingly, in lower income states where most urban development and densification currently occurs, evidence suggests a decline in deaths from certain infectious diseases in cities, but not due to better quality of life or decline in disease incidence. The decline has instead been attributed to increased antibiotic use, which has been shown to contribute to the acceleration of AMR (11,66,70). This exemplifies the complex role of urbanization as both an enabler and barrier to health threats (15,25,101), calling for more nuanced urban lenses to help us expose and understand the dynamics of threats like AMR.

Global health literature typically includes notions of societies with pre-conceived institutional and international organizational lenses, without considering the role and impact of socioecological interactions as UPE emphasises. By engaging with urbanization as a socioecological transformation deeply connected to the natural “One Health” world outside pre-conceived geographies of cities or states, and by assessing the ways human and more-than-human relationalities help shape environments that do not necessarily operate within these pre-conceived boundaries, UPE scholars analyse

under-exposed relations beneath and beyond societal angles normally entrenched within institutional scales and relations, as they focus on unsettling traditional notions of an urbanizing world. Thus, UPE theorizes a politicized urbanization of nature writ large – a process that is global in scope, but also locally situated and manifested through various forms and processes of urbanization (16,30), - as they relate to climate change and biodiversity degradation.

Following the call to integrate the political economy and structural causes underlying collapsing health ecologies in OH (55), while accounting for historical agency and the political parameters of human intentionality in nature-society relations (107), the next section engages UPE scholarship to suggest how a UPE lens can inform OH approaches to AMR. Rather than draw on a particular strand of UPE, we build on UPE's foundational propositions to explore how the main contributions of UPE scholars can inform the rationale for strategies addressing the environmental dimension of AMR and its interdependencies, as well as nature-society relationalities shaping AMR risks.

3.6 Mobilizing UPE scholarship to explore the sociopolitical ecologies of AMR and its interdependencies

As a critical social theory of urban environmental change, UPE has generated insights that help us understand the new realities and risks of the Anthropocene (13,108). UPE scholars Kaika, Swyngedouw, Heynen and others (26,107,109,110) pioneered and inspired further debates on how and why relationships between cities and environments are engendered by exploitative urbanization processes that – under conditions of accelerating environmental degradation – demand more sustainable socioecological relations.

For example, when Brenner considered early notions of an urbanizing world as “efforts to decipher the accelerated industrialization of capital in XIX Century Euro-America” (45), he noted the focus on local and global scales of human activity also served as a framework to justify the multitude of urban interventions that reproduce an exclusionary global history of environmental degradation, dispossession and uneven capitalist development (45). Drawing on his perspective reinforces the argument that a depoliticized notion of urbanization may conceal and thus reproduce the impact of these exclusionary forces on structural dimensions identified previously, posing risks to Global Health.

Several propositions developed by Brenner and others align with critical theories of urban change relevant to global health research and practice (27,45,111–113). In addition, UPE scholars explicitly connect urban expansion/concentration and environmental degradation in the face of climate crisis, emerging pandemic and AMR threats (15,30,64,67,114). As a multifaceted, interdisciplinary project, UPE scholarship allows a variety of access points to the multiple interactive relations of urbanization and nature (107).

In mobilizing UPE scholarship to inform approaches to address AMR, we draw on Tzaninis and colleagues’ (30) work that identifies five contributions of UPE scholarship to urbanization research and aligns with epistemological propositions and calls made by Kaika, Swyngedouw, and others for radical urban socioecological imaginaries in two distinct but related ways (26). Specifically, they first respond to calls for new ways of mapping ecologies of urbanization by (1) *redressing societal relations with nature*, which can inform approaches addressing the anthropogenic pressures

affecting AMR. Second, the summary of their five contributions align with calls to reorganize non-city geographies or urbanization by informing the (2) *rescaling of socioecological governance arrangements*. This rescaling can inform the design of governance arrangements addressing the commodification of health determinants and the privatization of commons resources management, which impact human-animal-environmental health systems. We summarize these five contributions into four categories that illustrate their potential to inform OH approaches to AMR (Box 3-1).

Box 3-1: Foundational propositions of UPE and contributions to urban research

UPE Propositions	Contributions to urban research
Redressing societal relations with nature	<ul style="list-style-type: none"> • Rethinking human and more-than human relationalities • UPE: situated and extended urbanizations
Rescaling of socioecological governance arrangements	<ul style="list-style-type: none"> • Addressing the externalities of AMR • UPE and planetary urbanization

3.7 Problematizing societal relations with nature at the interface of human-animal-environmental health systems

Rethinking human and more-than human relations

Tzaninis and colleagues’ emphasis on human and more-than-human relations shaping urbanization processes and forms considers human relationships with soil, water, air and even bacteria; they propose an alternative approach to urbanization that promotes non-hierarchical and non-exploitative socioecological spatial configurations with nature

(30). Similarly, Wolf uses the term “biocultural events” to describe the study of epidemics as the analytical blending of biological dynamics, environmental effects and social practice (114). Articulating an analysis of these human and more-than human relations in environments that accelerate AMR can guide a critical analysis of evidence and surveillance systems that monitor “biocultural events” accelerating AMR (64,65,115,116), as they relate to the effects of climate change and environmental degradation. Recent approaches to AMR primarily focused on a biomedical security logic of surveillance and behavioural change are not effective, as they disregard the impact of social determinants and neglect the effects of environmental degradation and climate change on AMR risks (68,81,82). Moreover, recent research suggests that AMR responses based on similar logics tend to reproduce northern-dominated biosecurity and biomedical innovation framings (65), triumphalist global health security approaches premised on technical and market integration efforts (64), whose lack of clarity conceals ethical considerations and value systems informing the conceptualization and design of OH-AMR governance responses (116). Drawing on UPE scholars’ work could re-scale and recast the governance lens to explicitly address this axiological gap and consider the root causes underlying AMU and AMR acceleration, to address upstream socioeconomic factors and structural drivers of AMR in water and sanitation programs, AMU and AMR awareness raising activities (117–119), and harmonization of OH surveillance systems that can reveal disparities in the distribution of environmental and health risks and benefits (120,121). Similar to the design of early warning systems where multiple biomedical and social dimensions are jointly analysed, governance responses concerned with productive engagements would leverage AMU and AMR

surveillance dimensions alongside behaviour change information, and measures addressing health inequities and environmental injustices accelerating AMR, related to climate change and biodiversity degradation (122). A renewed focus on supranational and state governance mechanisms that foster enabling policy environments and the progressive realization of AM stewardship would be imperative.

UPE: situated and extended urbanizations

UPE scholarship could also contribute by considering how urban environments have been locally shaped, politicized, and contested (123), and how they contribute to adverse health and environmental outcomes. UPE contributions build on Global South, Indigenous and abolitionist political ecologies, decolonizing theories and practices, and sites/products of relational connectivities such as Canadian pipeline politics (30,124). They also call for a focus on how extended urbanization processes and forms shape societal relations with nature (16). In approaching the UPE of zoonotic diseases, for example, Gandy proposes a zoonotic framing of capitalist urbanization, or 'zoonotic urbanization,' to rescale risk analyses that consider diverse extractive frontiers, zoonotic transfer zones, and accelerator landscapes for new or emerging diseases (79). Similar to the way Hinchliffe described how 'first world' biosecurity framings that ignore local conditions, market pressures and international competition may contribute to AMR in aquaculture in Bangladesh (67), considering these relations can inform the analysis of local and structural drivers of AMR and how they could be addressed in specific contexts.

Focusing on extended urbanization forms and processes can thus be a starting point to draw on UPE to reorganize and broaden human-centered approaches to

geographic inequalities in health that rely on social constructions of health and place (125). UPE could re-orient these approaches towards those that focus on “redressing societal relations with nature” to inform equitable and environmentally just strategies addressing AMR in human-animal-environmental health systems. A focus on relationalities in extended urbanization forms and processes requires recognizing their role in mediating, interconnecting and shaping urban realities that encompass such processes as suburbanization (30) and combine economic growth with spatial extension. From a UPE perspective, examples of these include “informal settlements, gated communities, tower estates, kampungs, desakota, peri-urban villages, ... classical subdivisions of ground-related housing.... suburban employment zones, office cities and aerotropolises, as well as recreational and infrastructural spaces” (30), agri/aquacultural sites and operations, or the entire socio-spatial mesh of relationships that constitute the planetary urban fabric, from the inner city to the agro-industrial relationships and factory farming sites that span the globe (27); many of which are regarded as AMR hotspots (69,70,72,126).

In approaching the ubiquity of extended urbanization as a global process at the same time composed by “disjunct fragments” that expand urban society, Keil notes that they reconfigure global peripheries in a world of complete urbanization, while being constantly “reassembled by human and more-than-human relationalities” (16). Rendering extended urbanization as a global scale process that incorporates human-nature relationalities reveals the often underexposed interdependences between ecologies and the urban as integral and mutually constitutive parts of extended urbanization processes.

The concentration of urban realities and the projection of peripheries, suburbs, vacation homes, satellite towns, and other forms and processes of extended urbanization are also influenced by hierarchies of global economies from the Global North (16).

As AMU became interwoven with the dynamics of modern societies and economies (66,74,127), acceleration of AMR in the environment has also become interwoven with globalized urbanization and the anthropogenic pressures that obscure inequalities. For example, Willis and Chandler (66) show that AMU in humans, animals and the ecosystem obscures health inequities and the adverse impact of accelerated human activity in our modern era. Through ethnographic research in East Africa, they explore how AMU became interwoven with the dynamics of modern societies and economies, becoming a “quick fix” for care in fragile health systems; for poor hygiene infrastructure; for productivity at local and global scales for humans, animals and crops; and a “quick fix” for inequality in “landscapes scarred by political and economic violence” (66). As we consider antimicrobials as infrastructure entwined with global systems and local demands of modern life (127), their role may obscure enduring health inequities and environmental pressures, suggesting that responses to AMR should also consider their underlying structural dimensions (96). By jointly framing the adverse impact of AMU on animals and crops in terms of productivity at various scales, Willis and Chandler also provide an opportunity to frame AMU in relation to global governance and economic forces shaping social and political determinants of AMR, which aligns with the theoretical framework exploring UPEs of AMR adapted from Brenner and Ghosh’s work (27).

The acceleration of AMR can thus be linked to a multitude of urbanization forms and processes currently addressed by “quick fixes,” which in turn relate to the anthropogenic pressures that produce the vulnerabilities (62) and socioecological transformations that are typically objects of UPE research.

In a predominantly urbanized world, a UPE lens shows that tackling AMR hotspots would entail their consideration as extended urbanization processes and forms subject to market pressures, international competition and hierarchies of global economies that shape AMR risks, while contending with the effects of climate change and environmental degradation.

3.8 Reorganizing socioecological governance arrangements at the interface of human-animal-environmental health systems

Addressing the externalities of AMR

UPE scholarship theorizes governance practices in the context of neoliberal organization of resources, practices of sustainability, circularity and resilience (30). A UPE analysis of commodification and privatization of structural determinants of AMR is particularly relevant for developing socioecological governance approaches that address the externalities of AMR governance responses. The concept of an “eco-scalar fix” – in which governance arrangements are rescaled by integrating an ecological ‘scale’ or dimension - is relevant in theorizing UPE-informed governance as “a process of rescaling and reorganizing governance as a strategy of either internalizing or externalizing socio-environmental externalities, or both, and thereby displacing conflicts and crises, often through the construction of (purportedly “natural”) ecological scales, which simultaneously depoliticize and repoliticize governance” (Cohen and Bakker,

2004, as cited in Tzaninis and colleagues, 2020, p. 9). Examples of eco-scalar fixes include promotion and protection of greenbelts in the context of urban development (128), addressing climate change through carbon governance, and considering access to/impact on water sources when planning new housing developments. These examples illustrate the potential of UPE to rescale governance arrangements that situate AMR risks in relation to its structural dimensions, as they relate to the effects of climate change and environmental degradation, thereby *adjusting the drivers* advancing AMR. Rather than prioritizing rationales that focus on policy compromises or economic optimization (129), governance responses designed to redress human-nature relations that accelerate AMR threats can use a UPE lens to make explicit connections between urbanization processes, infrastructure networks, global capital flows, resource distribution, environmental degradation, climate change and emerging AMR/pandemic threats (27,28,30,67,70,107,130–133).

Rather than being informed by rationales premised on technical or market integration efforts (64), OH-AMR governance responses guided by socioecological approaches to health and development (117,118) such as eco-scalar fix necessarily situate OH-AMR responses within broader concerns and responses to other global health threats (132,134–136).

By mobilizing an “urban lens” (137), AM-Environmental stewardship can align with pandemic prevention governance pathways that seek to address related existential threats (132,134). For example, AMR governance strategies could build on existing OH institutionalization efforts and link to broader concerns such as the Global Health Security Agenda, the Sustainable Development Goals or Universal Health Coverage

plans (138,139). Strategies could also be integrated within global health responses to zoonotic and emerging infectious diseases or food safety issues (121,140,141).

UPE and planetary urbanization

UPE scholars are engaged in reconceptualizing urbanization in a planetary framework that includes both traditionally urban and dispersed non-city geographies (30,107). As this includes an emphatic call for collective uses and the common good, UPE's theoretical contribution to a vision of planetary urbanization can inform a critical rescaling of socioecological governance arrangements in global health: not through prescriptive guidelines but rather by calling for a renegotiation of ecological, institutional and political perspectives on contemporary urbanization processes and forms that consider situated relationalities of urban life and polycentric forms of governance that look beyond pre-conceived scales and places (142–144). Camponeschi's research on integrative resilience in the face of technocratic responses to Covid-19 and climate change offers examples on how similar approaches grounded in situated relationalities in cities inform interventions that are locally relevant, responsive and 'bioecological' (145,146).

Engaging communities, civil society and other non-state actors in clarifying the factors that produce the vulnerabilities accelerating AMR would configure whole-of-society approaches that increase the visibility and contributions of these communities while facilitating policy outcomes.

The integrated OH approach to research, design and implementation of interventions to achieve better public health outcomes is a well-established approach used to address global health challenges such as AMR (147). OH approaches also

emphasize the importance of addressing health threats through joint work across multiple sectors. The Global Action Plan on AMR and subsequent UNEP and Tripartite guidance reflect OH approaches promoting the need for intersectoral engagements to rearticulate actions that address global health challenges at the human-animal-environmental interface (29,81,148,149).

The urban environmental dimension thus offers a salient interpretive frame, enhancing our understanding of how to rescale socioecological governance arrangements in response to the OH call to balance and optimize the health of people, animals and ecosystems by going beyond the organization of siloed governance arrangements within established OH sectors (133).

As national governments adopt intersectoral whole-of-government approaches to address the threat of climate change and environmental degradation (150,151), integration of AMR governance strategies within extant and expanding environmental stewardship presents opportunities to mobilize resources and leverage whole-of-government environmental stewardship measures that support AMR strategies and produce co-benefits to human and planetary health. Just as the concept of "health in all policies" emphasized taking health implications into account in all public policy development (across sectors, and at local, state, and global levels) (145,152), the mobilization of UPE in governance arrangements to address AMR would call for taking other sectors into account using an intersectoral whole-of-government approach that fosters shared CC-AMR governance pathways. A global commons perspective on AMR further compels society to consider the global implications of local actions.

At a community level, examples of responses that could inform whole-of-society approaches addressing the vulnerabilities triggering AMU in cities as they contend with other existential threats, could be informed by examples of community resilience-building, disaster response and preparedness, and climate change planning initiatives (146). Existing intersectoral OH platforms could be leveraged to consider intersections of health equity and sustainable development (138) to support equitable distribution of health and environmental outcomes across targeted groups and populations. Integration of AM-Environmental stewardship approaches through whole-of-government efforts could – for example – support enabling environments that address different aspects of global antibiotic infrastructures (63) beyond food supply chains (153) or the agricultural sector (135,136). Although shifting agricultural practices into more sustainable models is a challenge resisted within this sector as it would drive up costs and reduce efficiencies, incentives combined with judicious use of information systems within and across sectors, regulations and enforcement within enabling policy environments integrating AM-Environmental stewardship could progressively diminish antimicrobial use and support the necessary shift in approach (see figure 3-1 for an illustration of an enabling policy environments logical framework).

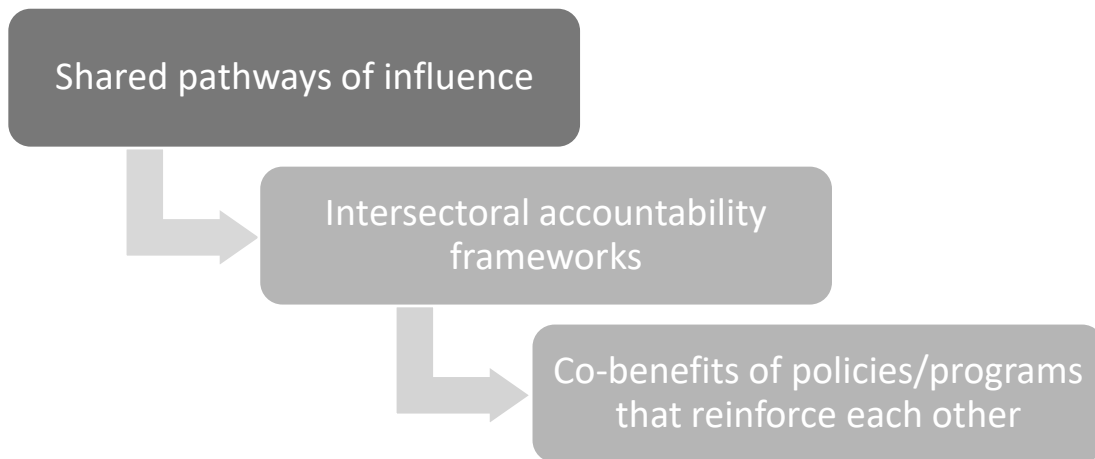


Figure 3-1: Enabling policy environments would be based on shared governance pathways that inform intersectoral accountability frameworks and produce co-benefits

Transnationally, ensuring the World Organization for Animal Health, World Health Organization, World Trade Organization, Food and Agriculture Organization of the United Nations and UNEP recognize the inequities and environmental injustices of AMR as existential risks would reinforce national AM-Environmental stewardship governance approaches.

UPE scholarship can also assist in mapping ecologies of urbanization by *redressing societal relations with nature* that reorient AMR policies beyond a global health security logic of surveillance and behavioural change, towards redressing the health inequities and environmental injustices which produce the vulnerabilities that contribute to AMR and broader environmental threats across human-animal-environmental systems. In summary, UPE scholarship assists in reorganizing non-city geographies or urbanization by *rescaling socioecological governance arrangements* that integrate the local and structural determinants of AMR alongside broader environmental concerns into whole-of-government and whole-of-society efforts.

3.9 Mobilizing UPE to inform OH responses to AMR and Environmental threats

Despite progress in the implementation of OH-AMR governance approaches (78,141,154,155), and growing recognition of the co-benefits generated by measures jointly addressing human-animal-environmental health (104,134,156,157), effective institutionalization of these governance approaches remains a challenge. Common barriers to effective institutionalization include market failures that externalize the costs of AMR and impact other structural drivers (63,158), and include public AMR governance responses characterized as fragmented, lacking in OH intersectoral coordination (159,160). European Union guidance to reduce agricultural impact on climate change has been met with challenges (161,162). Given the political resistance, reluctance to address such issues in other states has hampered progress, suggesting the need for more consultative, supportive and anticipatory regional and state governance and policy approaches to address the concerns of groups adversely affected. UPEs of AMR could inform the integration of AMR governance and Environmental stewardship measures that consider existing governance externalities and fragmentation.

Resulting synergies of shared governance pathways would enhance opportunities for the design and implementation of whole-of-government/whole-of-society AM-Environmental stewardship, which would generate co-benefits to human and planetary health (163). A logic model and associated framework for enabling policy environments would enhance governance and foster the progressive realization of reinvigorated stewardship measures. In practice, efforts to design enabling policy environments for AM-Environmental stewardship measures could be modeled on incentive-disincentive frameworks (164,165) similar to Environmental stewardship

efforts focused on green and resilient economic recovery (134), or on channels of influence and mutually supporting frameworks (132). Strategies include industry self-regulation in response to consumer demand in Canada (166). Box 2 (adapted from Petrie, 2021) outlines challenges that could become opportunities for governments to pursue AM-Environmental governance pathways that support intersectoral accountability frameworks.

Box 3-2: Challenges in fostering shared AMR-Environmental governance pathways

- Build evidence of win-win solutions rather than trade-offs between AMR governance strategies and other commitments to planetary health (i.e., the Pandemic Treaty, climate change and Greening Government Strategies, whole-of-government Environmental Stewardship approaches, and other economic and social goals). Address AMR-related environmental degradation while promoting sustainable production and consumption patterns (81,134).
- Clarify co-benefits of AMR-environmental policies, e.g., global-, state- and societal- level measures to reduce environmental pollution affecting AMR include fostering sanitation systems in LMICs that reduce transmission and evolution of AMR while promoting biodiversity gains (81,134).
- Public R&D in the development of new technologies that catalyze private sector involvement in solutions to address AMR in the environment, e.g., AM-Environmental stewardship could be accompanied by subsidies to monitor and treat environmental pollution, e.g. untreated waste and antibiotic manufacturing pollution in the environment (32,81,164).
- Clarify the increasing cost and risk of inaction on environmental threats to human health related to AMR. AMR is a leading cause of death worldwide, with higher burden in LMICs (167) that will lead 24 million people into extreme poverty by 2030. Expected global benefits of AMR containment are far greater than the investment costs. “Assuming that just 50 percent of AMR costs will be avoided by vigorous AMR containment efforts, the expected cumulative global benefits from AMR containment in 2017–2050 range between \$10 trillion and \$27 trillion, far greater than the investment costs of \$0.2 trillion (168).” The cost of investment in climate action and protecting biodiversity to prevent pandemics caused by similar health threats occurring at the intersection of humans, animals and the environment was reported as much less than the cost of a pandemic (82,134,169).

- Increase awareness of fiscal risks for governments from AMR-related environmental degradation, e.g., ignoring the fiscal impact of government policies and subsidies that affect the environmental dimension of AMR obscures the role of governments enabling spatial and relational vulnerabilities associated with environmental dimensions of AMR (i.e., the financial dimension of AMR).
- Increase recognition of the inequities of AMR associated with climate change and environmental degradation, both in terms of who causes and is most impacted by AMR (4,11,82).
- Greater transparency of AMR-related environmental risks and their potential economic and financial impacts strengthens incentives to mitigate the risks through changes in risk premia on government bonds, a tax on antimicrobials, regulation of AMU reinforced by audit and enforcement.
- ‘Frame’ AMR-Environmental initiatives in ways that foster political coalitions for difficult policy change, e.g., presenting win-win options; the increasing costs of inaction; earmarking revenues from environmental and AM taxes to specific incentive programs, including re-configuration of agricultural processes and compensation for those most negatively affected.

3.10 Conclusion

In an urbanized and interconnected world, global AMR governance remains characterized by fragmented, complex non-linear arrangements that often lack intersectoral coordination (159,160,170). By fostering a lens on urban life, UPE clarifies connections between AMR and broader concerns affecting all life on earth and the systems upon which it depends. A UPE lens not only addresses the structural determinants of AMR as local and global drivers, it also situates them in relation to planetary urbanization forces and to existential threats addressed in commitments to pandemic prevention and environmental stewardship. Advancement of shared governance pathways through a “whole of government” approach informed by a UPE lens presents an opportunity to engage global forces shaping the co-determinants of antimicrobial threats and environmental degradation. Intersectoral accountability frameworks would strengthen action of sovereign strategies that move beyond rhetoric to adopt and implement international agreements, align and synchronise departmental

mandates, budgets and operational plans that would foster more collaborative, equitable and sustainable approaches by adjusting the structural drivers of AMR. As a “new frame for understanding the relationship between cities and the environment in contemporary urban policy” (171), integrating UPE as both an epistemological frame and a guide to practical politics of sustainability and human-nature relationships contributes an understanding of how AMR and other systemic threats may be confronted in policy and practice.

Declarations

Ethics approval and consent to participate

Not Applicable.

Consent for publication

Not applicable.

Availability of data and materials

Not applicable.

Competing interests

We have no financial or non-financial competing interests to be declared.

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Chapter 4 – One Health governance of antimicrobial resistance seen through an Urban Political Ecology lens: A Critical Interpretive Synthesis

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4.1 Preface**Relation between texts**

This manuscript mobilizes the theoretical foundation developed in Chapter 3 to inform a critical interpretive synthesis (CIS) of articles discussing OH-AMR governance approaches published in peer-reviewed journals.

Contribution of Authors

RA conceived the idea for the critical interpretive synthesis with support from MW. RA led the design methodology, devised the search strategy, led the data collection and analysis and wrote the first draft of the manuscript. RG assisted with data analysis, study selection and description of methods. MW substantially revised the manuscript. MW and RK provided valuable methodological and subject-matter expertise. All authors have read and approved the final manuscript.

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4.2 Abstract

Background: Antimicrobial resistance (AMR) is an evolutionary mechanism that threatens animal and ecosystem health, agriculture, farming, water, hygiene and sanitation systems, creating risks not only for human health, but for society and the systems upon which it depends. Global health governance draws on a variety of One Health (OH) approaches to address AMR, however effective state implementation of these approaches faces several constraints, ranging from governance and implementation challenges due to the interconnected nature of AMR with other global health threats at the human-animal-environmental interface, as well as local and structural socioecological factors that are generally not considered within governance approaches but affect AMR policy outcomes.

Objective: The aim of this paper is to clarify the extent to which scientific literature has situated OH-AMR governance responses in relation to five identified socioecological dimensions affecting the outcomes of AMR interventions: broader global health threats and concerns, global governance frameworks, socioeconomic factors, health equity and environmental justice considerations.

Methods: Informed by an Urban Political Ecology lens, this critical interpretive synthesis was guided by the CIS methodology of Dixon-Woods et al that aims to identify articles that address OH governance of AMR and deductively analyse the extent to which they incorporate socioecological dimensions of OH-AMR.

Findings: Our search identified 18 articles that situate OH-AMR arrangements within the five socioecological dimensions. The role of global governance frameworks in shaping specific state governance arrangements was rarely the object of analysis across the selected studies.

Conclusion: The CIS sheds light on the interconnections between urbanization processes and forms, AMR risks, global health threats, and the broader ecological challenges that impact our planet. In addition, the synthesis deepens our understanding of the multifaceted challenges posed by AMR, calling for a critical evaluation of existing global and state governance approaches while offering a compelling case for the adoption of a UPE lens to inform future efforts in addressing AMR and related global health challenges.

Keywords: urban political ecology, governance, AMR, socioecological dimensions

4.3 Introduction

Antimicrobial resistance (AMR) is regarded as a leading cause of human death, with recent estimates showing that resistant bacteria caused or contributed to nearly 5 million deaths worldwide in 2019 (1). AMR is an evolutionary mechanism accelerated by antimicrobial misuse or other anthropogenic activities (2–4) affecting the evolution of microbes within natural and built environments. AMR threatens animal and ecosystem health, the viability of food systems, agriculture, farming, water, hygiene and sanitation systems (4–8), representing a threat not only to human health, but to society and the systems upon which it depends.

Although the threat AMR poses was considered as early as the first use of penicillin in the 1940s (9), the scientific community and policymakers only seriously considered the broader socio-economic and structural factors triggering antimicrobial use (AMU) as the twenty-first century unfolded (10). Since then, stewardship strategies that address the multidimensional nature of AMR have begun to consider structural factors (11,12), relations with other global health threats (13,14), the influence of global governance frameworks (15,16), socio-economic factors (17,18), health equity (11,19) and environmental justice concerns (20,21).

In assessing the structural factors associated with AMU and AMR, Willis and Chandler delineate how antimicrobials are used as a “quick fix” to compensate for healthcare deficiencies, to deal with impacts of social inequality, and to overcome productivity challenges for humans, animals, and crops (22). Focusing on AMR hotspots, Hinchliffe discusses the effect of global governance frameworks and economic demands, namely ‘first world’ biosecurity framings that ignore local

conditions, market pressures, and international competition on AMR in the aquaculture sector in Bangladesh (23).

Studies focusing on the interdependencies of AMR and other global health threats highlight links to pandemics, climate change, pollution and biodiversity degradation (13,14,24–27). Despite knowledge gaps underlying these causal relationships, policymakers increasingly try to address the interdependencies of AMR and other global health challenges through governance responses informed by a One Health approach (28–31).

One Health has been defined as *“an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and inter-dependent. The approach mobilizes multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for clean water, energy and air, safe and nutritious food, taking action on climate change, and contributing to sustainable development”* (32).

Since the launch of the Global Action Plan (GAP) on AMR in 2015 by the tripartite WHO-FAO-WOAH (33), global governance frameworks influence the development of National Action Plans (NAPs) strongly aligned with One Health (OH) and GAP’s five overarching objectives (16): i) improve awareness and understanding of AMR, ii) strengthen the knowledge and evidence base through surveillance and research, iii) reduce infection through sanitation, hygiene and infection prevention

measures, iv) optimize AMU in human and animal health, and v) develop the economic case for sustainable investment in new medicines, diagnostic tools, vaccines and other interventions.

An increasing number of studies explore the socioeconomic determinants fostering AMU and AMR. In an urban context of social and health inequalities, AMR has been linked to limitations in governance and deficient urban infrastructure (6,34–37). A study by Chandler also situates AMR risks within broader political economy and structural factors influencing pathogen exposure and the ways informal urban settlements shape behaviors and practices, pointing to the lack of AMR studies bringing urban planning into conversation with public health policy (38).

Studies focusing on urbanization similarly adopt a more holistic approach, calling for more equitable and environmentally just urban infrastructure to address urban health threats. A Lancet Commission on water, sanitation, and hygiene (WASH) suggests that improved WASH systems in low and middle income countries (and in high income countries, vis a vis persistent colonial legacies) can be a pathway to social and environmental justice efforts to address climate change and AMR (20).

While global health responses can draw on a variety of OH tools to simultaneously address AMR and other OH threats (3,26,31,39), effective implementation of responses face governance challenges. These challenges include addressing the effects of market failure that enable the consequences of antimicrobial overuse to be externalized to other sectors thereby inadvertently creating its structural drivers (11,40); institutionalized AMR governance responses characterized as fragmented, lacking in OH intersectoral coordination (41–44); OH-AMR responses that

tend to reproduce Northern-dominated biosecurity and biomedical innovation framings (12,15); and triumphalist global health security approaches premised on technical and market integration efforts (2), whose lack of clarity conceals ethical considerations and value systems informing the conceptualization and design of OH-AMR governance responses (45).

Successful AMR interventions must therefore contend with governance and implementation challenges, the interconnected nature of AMR and related global health threats, health equity and environmental justice concerns. A focus on the development of enabling policy environments to support enhanced institutional responses addressing AMR have only recently been proposed (31,46–48), but so far no evidence exists that similar approaches have been fully implemented. Analysing evidence on how AMR approaches described in the literature account for similar implementation challenges align with recently defined research priorities calling for enhanced cross-cutting strategies to integrate and deliver better outcomes of AMR interventions in resource-limited settings (49). The aim of this paper is thus to clarify the extent to which scientific literature has situated OH-AMR governance responses in relation to these challenges and concerns.

Furthermore, the paper is additionally specific in that it notes that the emergence and recognition of the threat posed by AMR roughly coincides with the majority urbanization of the world. Since the turn of the century more than half of humans have lived in cities and urban environments and some scholars have coined the phrase “planetary urbanization” to suggest that we now live in a completely urbanized society (50–53). This synthesis approaches planetary urbanization as a conceptual tool that

involves not only "...an intensification of city-building processes, but the remaking of territories and political ecologies beyond metropolitan centers, whether in zones of high-intensity agro-industrial and extractive capitalism, or in more remote hinterlands, forests, and oceans that are being more directly subsumed into global circuits of capital..."

(Brenner and Ghosh, 2022, p. 2).

Given the broad range of health equity and environmental justice concerns, complex socioeconomic factors, governance and implementation challenges impacting successful outcomes of OH-AMR approaches in this globally extended urban world, an Urban Political Ecology (UPE) lens that accounts for these 5 dimensions and critically examines the socioecological (8,54) interactions of AMR will be used as the theoretical framework guiding our analysis.

4.4 Methods

Theoretical framework

We draw on UPE theory to inform the lens used in this critical interpretive synthesis (CIS). UPE considers societal relations with nature in cities and urbanized environments as mutually constitutive processes and forms of urbanization, as opposed to traditional notions of urbanization that can be characterized as approaches that justify the accelerated accumulation of capital and human activity, environmental degradation, dispossession and uneven development. A central notion that captures the way UPE understands these societal relations with nature is "urban metabolism", which includes all manner of technical, physical, biological, social, economic and cultural processes of material exchange that sustain cities (50,55–59). Rather than looking at nature in cities, UPE is concerned with the urbanization of nature in a globally extended process of the

spread of urban life (53,60). As a critical social theory of urban and environmental change, UPE is a useful lens to broaden siloed understandings of AMR, while contending with the effects of climate change and environmental degradation. UPE theory unsettles traditional epistemological dualisms (eg: urban vs. rural) that obscure the detrimental impact of human activity on human-animal-ecological systems (53,55). Similar to OH approaches that refer to anthropogenic activities as societal influences impacting the health and well-being of humans, animals and the ecosystem (61), UPE theory also problematizes exploitative urbanization processes and the effects of human activity on the planet in terms of regenerative societal relations with nature (59,60,62,63).

The analysis also considers processes and forms of urbanization across hierarchies and networks of spatial scales to guide a practical politics of sustainability and human-nature relationships. By engaging with critical notions of urbanization as socioecological transformations connected to the operational definition of OH, the theory guiding this synthesis adopts an urban dimension that problematizes the impact of urbanization on human-animals-ecosystem health, and follow calls for the use of socioecological frameworks to inform the creation of enabling policy environments addressing AMR (46,64).

In drawing on UPE theory to inform the overarching approach of this synthesis, we explore connections between “political ecologies of infectious diseases” and “planetary urbanization or extended urbanization” processes and forms proposed by Brenner and Ghosh (50), Ali et al. (51) Treffers et al. (65) and zoonotic connections of human and nonhuman environments as discussed by Gandy (66). Brenner and Ghosh

characterize political ecologies of infectious diseases as mechanisms underlying the intensification of microbial traffic and the production of infectious diseases in a world considered completely urbanized. We also adapt the approach Ali et al. (51) propose to consider AMR as not only determined through biophysical processes, but also constructed out of a particular set of social and spatial relations which are mediated through the landscape. A UPE approach would thus explore the spatialities of AMR as it relates to planetary and extended urbanization processes and forms.

OH-AMR governance responses informed by a UPE lens, in turn, would emphasize the necessity to consider the health inequities and environmental injustices of AMR, while addressing the collective need for “*clean water, energy and air, safe and nutritious food, taking action on climate change and contributing to sustainable development*” (32,67).

As a socio-ecological approach premised on sustainable nature-society relations, exploring the relations between political ecologies of AMR and planetary urbanization includes an emphatic call for collective uses and the common good (53,60), which broadens the focus of AMR approaches to consider structural and local determinants shaping AMR risks, while situating these risks in relation to planetary urbanization forces and existential threats addressed in broader commitments to global health and sustainable development. UPEs of AMR would consider the impact of planetary urbanization processes on health determinants and commons resources, as these structural determinants influence local socioeconomic demands and sociopolitical ecologies (67).

We refer to extended urbanization processes and forms shaping societal relations with nature, *“as development occurring at the peripheries of metropolitan cores and including a full range of non-city geographies that are now evident in the suburban (or post-suburban) zones and hinterland areas”* (51,68). Similar to the way Hinchliffe described how local and structural drivers affect AMR in aquaculture in Bangladesh, a focus on extended urbanizations informs broader analyses that consider socioeconomic factors producing vulnerabilities of AMR (69).

Similar forms and processes of extended urbanization have been cited by several authors as AMR hotspots and drivers (5,6,38,70). Examples of hotspots accelerating AMR include informal settlements (6), infrastructural spaces (53), agri/aquacultural sites and operations (23,70), agro-industrial relationships (71), or *“the entire socio-spatial mesh of relationships that constitute the planetary urban fabric, from the inner city to the agro-industrial relationships and factory farming sites that span the globe”* (50); many of which are also influenced by hierarchies of global economies from the Global North (22,68).

As antimicrobial use (AMU) became interwoven with increasing socioeconomic demands and the dynamics of modernity and globalization (12,22,52,72), the acceleration of AMR also became interwoven with urbanization and the anthropogenic activities broadly characterizing societal relations with nature. We therefore mobilize UPE theoretical frameworks that explore connections between political ecologies of disease and planetary and extended urbanization, and OH-AMR governance responses in relation to similar socioecological concerns affecting societal relations with nature. We frame the socioecological concerns affecting AMR approaches in terms of five

dimensions that are typically objects of UPE approaches: global health threats and broader concerns, global governance frameworks, socioeconomic factors, the health equity and environmental justice concerns that are also enshrined in the recently proposed operational definition of OH. The objective of this CIS is to clarify the extent to which scientific literature has situated OH-AMR governance responses in relation to the five identified socioecological dimensions affecting the outcomes of AMR interventions.

Methodology

This study was guided by the CIS methodology of Dixon-Woods et al (73) that aims to capture key ideas and to offer reflections about the literature to inform future debate and scholarship, rather than systematically reviewing every article relevant to the research question and aggregating every finding. Adopting this methodology to synthesize a diverse body of evidence allows us to integrate concepts by focusing the product of synthesis not on aggregations of data, but on interpretations of the ways in which OH-AMR governance responses are influenced, draw on, and situate their problematics within broader critical socioecological epistemologies.

According to Bernstein and Cashore (43), governance models for single-issue international or transnational regimes no longer capture governing arrangements for many of the most pressing global environmental problems. Efforts to address some of the global health threats linked to AMR such as climate change, pollution, and biodiversity degradation have been governed by arrays of mechanisms including legal, non-legal, governmental, and non-governmental arrangements that require multisectoral governance arrangements and rationales that move away from policy compromises or economic optimization (43,74), to focus on enabling environments (75) informed by

theory-guided approaches that allow more systematic, effective and sustainable interventions (76,77).

Bernstein and Cashore understand influence as explicit efforts at governance, the latter constituted by two elements: 1) steering and authority to increase coherence, and 2) synergies among governance mechanisms (74). The ultimate form of this international/transnational influence is the institutionalization of international laws and norms within state policymaking.

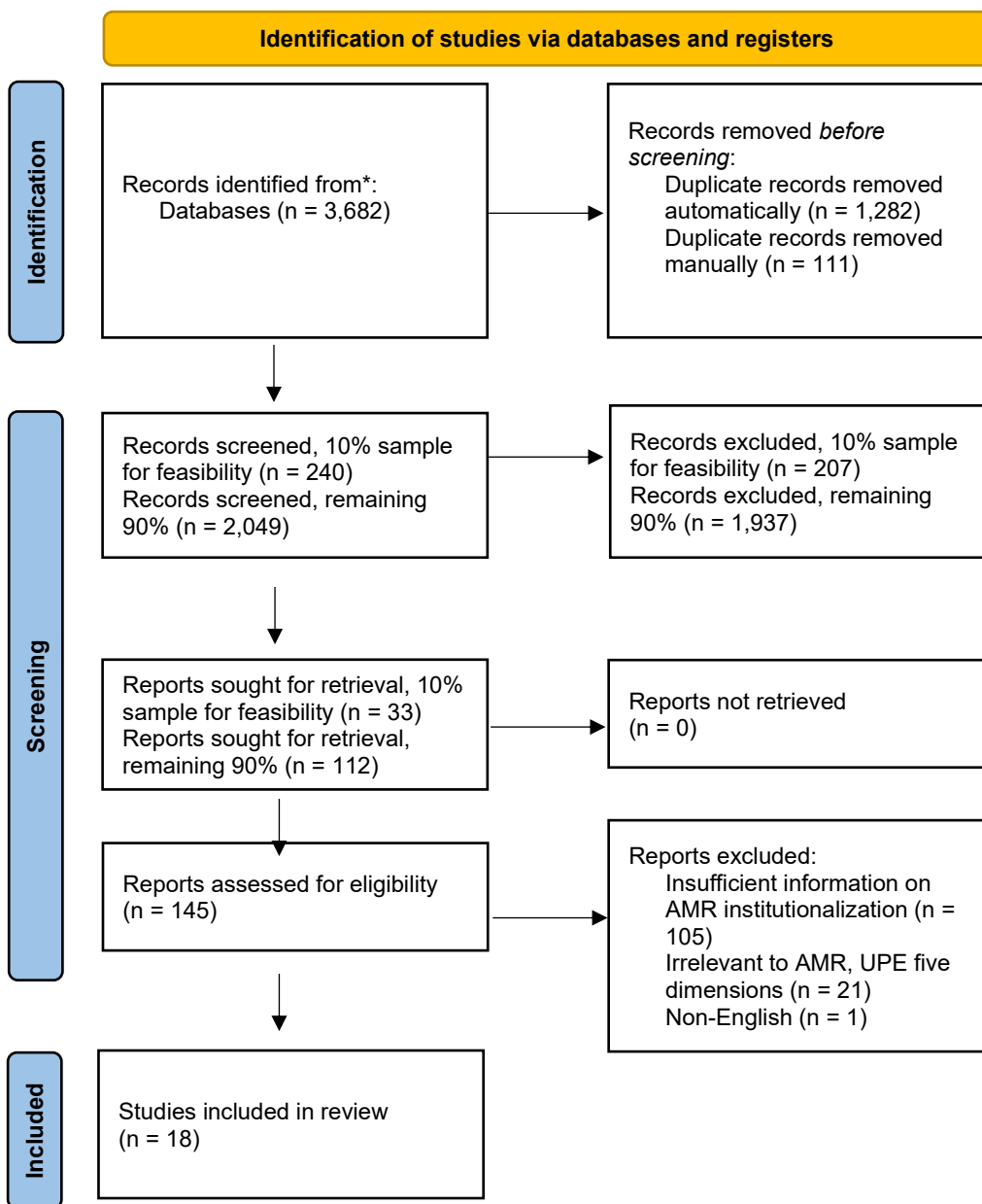
Institutionalization is defined as the action of establishing something as a convention or norm in an organization or culture (43,74). The eligibility criteria initially included mention of: 'actor' or 'institution'; 'instrument' or 'document' institutionalized; and how influence occurred. Articles were included for data extraction if they discussed purposeful efforts of institutions or actors that function above the state-level (e.g. international) to steer the policymaking and behaviour of states. The influence of these international institutions or actors on state governance were understood as explicit international and transnational efforts on domestic firm policies and practices.

The rationale for inclusion was to select articles discussing governance arrangements for AMR and such broader issues as the environment, to ensure theoretical developments would entail reflexive iterations informed by data extraction and coding. For example, articles discussing claims of authority exercised by actors or institutions that draw on international laws and norms recognized by targeted actors would be selected. In keeping with the five socioecological dimensions affecting AMR (i.e. global health threats and broader concerns, global governance frameworks, socioeconomic factors, health equity considerations, environmental justice

considerations), these dimensions would be coded and serve as further eligibility criteria for article inclusion. The variables used for data extraction include: 1) author; 2) title and year; 3) study design; 4) intervention discussed (i.e. AMR approach); 5) geographic coverage; 6) global health/broader issues; 7) global governance issues; 8) health equity; 9) environmental justice; and 10) socioeconomic factors.

To test the above approach, two authors (RA and RG) developed a landscape scan of actors and institutions involved in examples of AMR institutionalization. Literature searches to identify potentially relevant documents were carried out in OVID PubMed, OVID Global Health, OVID Embase, Web of Science and Scopus search engines and databases during March 2022. Of 3,682 results, 1,282 results were excluded due to duplication, resulting in 2,400 results remaining. A 10% sample (i.e. 240 articles) was selected at random on August 6, 2022 to test the article inclusion/exclusion approach. 2,160 articles remained after removing duplicates and the 10% sample. Of these 2,160 articles, 111 were excluded due to manual finding of duplicates, 1,937 articles were excluded based on title/abstract screening, and 112 articles were saved for full-text screening. 33 articles from the 10% sample screening feasibility test were deemed relevant based on the inclusion criteria and were added to the 112 articles also deemed relevant, for a total of 145 articles that received full-text screening and data extraction. Over multiple iterations of data extraction, and after several discussions to refine the objectives and criteria for article selection between RA and RG, 18 articles were ultimately included in the CIS. A PRISMA diagram illustrating this article inclusion/exclusion process may be found on the next page (78).

Figure 4-1 PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

For more information, visit: <http://www.prisma-statement.org/>

4.5 Findings

In total 18 studies describing AMR approaches were included in the paper. Most articles included analyse OH interventions addressing AMR at national and regional levels, and those discussing factors that influenced the success of local interventions. Our findings synthesize analyses that situate OH-AMR arrangements within broader global health threats and concerns, socioeconomic factors, health equity and environmental justice considerations. The role of global governance frameworks shaping specific arrangements is rarely the object of analysis across the selected studies. Our findings are organized according to the 5 dimensions influencing UPEs of AMR.

Global health threats and broader concerns

While authors did not explicitly focus on challenges related to the integration of AMR approaches with other global health threats or broader concerns, studies refer to the interconnected nature of AMR and consider these connections within responses addressing healthcare-associated infections (79–83), zoonotic and emerging infectious diseases and food safety issues (81,84,85).

A common theme among studies focused on interventions integrating AMR, global health threats and broader concerns was the *institutionalization of the OH approach*. When studies discussed OH institutionalization (82,84–86), they found AMR is considered alongside measures to address zoonosis (84,85), food safety issues (81,84,85) and environmental health hazards (84,85).

Integrating AMR approaches effectively through OH institutionalization requires effective alignment of governance structures, policies, regulations and plans across

different sectors. Evidence of AMR approaches considering global health threats consider the institutionalization of OH within existing disease surveillance programs, through the implementation of NAPs on AMR, harmonization of policies, and link to broader commitments.

Existing disease surveillance programs and preparedness systems could be leveraged to institutionalize OH approaches that address AMR and other global health threats (84), if resources are effectively mobilized. In Uganda and Thailand, studies focusing on the adoption of OH approaches to inform integrated AMR surveillance systems highlighted the need for improved data collection for informed decision-making and integration of intervention strategies (87,88).

The integration of AMR and Global Health responses through NAPs and strategic frameworks was highlighted by authors that consider challenges related to harmonization of policies and plans (46,47,83). In a study discussing multisectoral coordination of AMR responses, authors mention opportunities to integrate AMR approaches within existing programs such as HIV/AIDS, tuberculosis, malaria, safe delivery and neonatal care, and food safety and quality (47).

When an AMR approach is considered a cross-cutting strategy within food safety and national drug policies, authors emphasize that policy coherence should be scrutinized to avoid duplication and increase efficiency (83). Whereas India's NAP briefly references the need to align AMR containment measures with existing vertical health programmes such as HIV or vector borne disease control programs, authors also emphasize that there are no supplementary or publicly available documents outlining the mechanisms for implementing these linkages (46). Other AMR approaches

amenable to cross-cutting strategies include improving infrastructure for water and sanitation, infection prevention and control, strengthening/continuing education of frontline healthcare workforce to reduce reliance on antibiotics, leveraging point-of-care testing and mobile app-based health interventions for diagnosis and surveillance (46).

The integration of AMR containment measures within broader concerns is mentioned in a study that highlights integration challenges (47). The integration of AMR approaches within the Global Health Security Agenda (GHSA) draws on the GHSA AMR action package and started with stakeholder engagements, on-site situational analysis, and desk review of key documents such as baseline WHO Joint External Evaluation Reports and AMR country documents that assisted in the development and implementation of identified priorities. While not explicitly focused on the integration of these broader concerns, the need for adequate resources and operating procedures were indicated as potential challenges in leveraging the integration of AMR within the GHSA, the Sustainable Development Goals (SDGs) mechanisms and Universal Health Coverage (UHC) efforts (47).

Global Governance frameworks influencing AMR approaches

As purposeful efforts of international institutions and actors to steer national policy and action on AMR (43), the influence of global governance frameworks is not explicitly discussed by authors even though they are a common feature of AMR interventions. These frameworks play a crucial role guiding, coordinating, and supporting AMR responses at national and international levels.

The significant influence of UN quadripartite agencies WHO-FAO-WOAH-UNEP shaping AMR approaches can be observed through the adoption of the OH approach by

nearly all studies included in this review (AMR approaches that do not mention OH tools and guidelines were conducted before the OH approach was adopted by the UN in 2015).

Examples of AMR policies influenced by the OH approach were the focus of studies discussing the alignment of OH guidelines and strategies (47,83,84,86,89), funding for OH initiatives addressing AMR (48,83,85,88,90), surveillance and data sharing (86–88,90), and institutionalization of AMR action plans (46,48,81,83,85,86,89–91). By incorporating guidelines, strategies and plans, countries demonstrate their alignment with global guidelines and governance frameworks advanced by UN agencies.

The influence of intergovernmental organizations seems less pervasive but relevant for the included studies. Through the Africa Centres for Disease Control and Prevention, the African Union organized the discussion of a regional framework for AMR containment in Ghana (90). Informed by an AMR stewardship program addressing healthcare-associated infections in Scotland (92), the European Union aligned guidance and use of standardized surveillance systems, and developed roadmaps to tackle AMR in food safety systems to facilitate the access of African, Caribbean and Pacific countries to international markets (85).

International development agencies also have an important role providing funding and support to initiatives addressing AMR in LMICs (48,90). The US Agency for International Development (USAID) provided financial support and technical assistance to build and strengthen multisectoral coalitions in Ethiopia, Namibia and Zambia, catalyzing action against AMR through programs focused on access and rational use of

pharmaceutical products (48). The Swedish International Development Agency (SIDA) provided financial and technical support to Ghana's National Platform on AMR (NPAR) which include public and private agencies, academic and research institutions, professional bodies, and civil society organizations (90). SIDA's support facilitated the generation of data to inform the development of Ghana's NAP, assisted in stakeholder analysis, research and awareness raising related to AMU and AMR. The Danish International Development Agency (DANIDA) also provided financial and technical support to NPAR through the Antibiotic Drug Use, Monitoring and Evaluation of Resistance (ADMER) Project, a research initiative aimed at promoting prudent antibiotic use in human health. DANIDA supported human surveillance, stakeholder analysis, and AMU/AMR awareness raising at community level (90).

The UK Department of International Development (UK DFID) also provided financial support to the NPAR within the ADMER project; UK DFID provided capacity building and infrastructure support for IPC and antibiotic stewardship, AMU or AMR surveillance in humans, animals, aquaculture and the environment (90). USAID initiatives were carried out with support from the Ecumenical Pharmaceutical Network, whereas initiatives led by Swedish and British counterparts were respectively carried out with support from ReACT and the Fleming Fund (90).

Programs by national professional associations were also mobilized to inform AMR responses in jurisdictions where such professional associations typically do not operate (79,92). In Taiwan, the antimicrobial stewardship program (ASP) was informed by guidelines set by the Infectious Diseases Society of America and by the Society for Healthcare Epidemiology of America (79). The Taiwanese ASP focuses on

strengthening surveillance of healthcare-associated infections (HAIs), and involves the establishment of a national intersectoral antimicrobial stewardship taskforce that included healthcare professionals, veterinarians, agriculturalists, government and media representatives, consumers and other stakeholders. The Scottish ASP adopted data collection and evaluation practices from the Welsh AMR Programme, and adopted core components from the Swedish Strategic Programme for the Rational Use of Antimicrobial Agents and Surveillance of Resistance project (STRAMA) (92). The Scottish Antimicrobial Prescribing Group (SAPG), responsible for coordinating and delivering the Scottish ASP, is part of the Scottish Management of Antimicrobial Resistance Action Plan.

Health equity concerns

Health equity concerns were not found to be explicitly integrated within AMR approaches in the articles included. This omission may limit the achievement of equity gains since approaches that do not explicitly consider equity concerns tend to overlook health disparities, specific needs, equitable representation and accessibility to services that would ultimately affect outcomes of AMR approaches (45). By including a focus on addressing health disparities and by considering social determinants of health within AMR strategies (34), these outcomes can be accounted for in more equitable and inclusive ways.

While AMR approaches did not explicitly address health equity concerns, some studies refer to the diverse ways in which AMR creates inequalities. One study used a governance framework to guide a content analysis of eleven NAPs in Southeast Asia that includes an equity component (81). Chua et al analysed equity in terms of

accessibility and affordability of healthcare and quality antimicrobials, and found that most NAPs included accounted for equity in accessibility and affordability of healthcare services and antimicrobials, while nearly half the NAPs included research to guide considerations concerning the socioeconomic burden of AMR in their Action Plans. Gender considerations were not included in the NAPs.

In Nigeria, a study discussing OH operationalization mentioned Antimicrobial Stewardship Programs (ASP) and the creation of a technical working group on AMR to enhance AMU in a context of poor infrastructure, low vaccine uptake and low level of AMR awareness among public and healthcare professionals (86). In Ghana, a study focusing on national level dialogue to establish AMR policies and plans discussed the importance of engaging diverse stakeholders in an AMR platform to advocate for AMR awareness and education programs (89).

Studies discussing ASP addressing healthcare-associated infections (HAIs) mention improved clinical outcomes and the creation of intersectoral coordination groups to enhance AMU and AM prescribing in Taiwan, Scotland, Sweden, and Tanzania (79,80,91,92). AMR approaches focusing on improving clinical outcomes could also focus on ensuring equitable distribution of improved clinical outcomes among vulnerable groups that are disproportionately affected by AMR risks.

Another study highlights the need to focus on addressing health disparities while linking AMR to broader concerns as measures that would create an enabling environment for concrete action on AMR in India (46). While finding that NAPs are comprehensive and in line with the WHO Global Action Plan on AMR, authors highlighted the need for targeted interventions that consider socioeconomic factors

influencing access of vulnerable groups to quality healthcare services, functional water and sanitation facilities as system-wide approaches instrumental to address AMR.

A less common theme explicitly discussed across selected studies is the importance of leveraging donor support, that is highlighted in the context of multisectoral coordination in LMICs, and in the development of AMR National Action Plans in Ghana (47,90). These studies mention the impact of donor support strengthening human AMR surveillance and WASH programs in healthcare facilities in Ghana, as well as support for coordination platforms that consider the intersections of health equity and sustainable development.

While health equity concerns are not explicitly integrated within studies assessing AMR approaches included in this CIS, health equity concerns have been a specific aspect of a completely urbanized world. In this context, efforts would ensure that plans and policies explicitly consider the social determinants of health and address structural disparities and conditions that inadvertently and systematically spread AMR, while bringing into sharp relief the challenges of achieving urban health equity and environmental justice (93).

Socioeconomic Factors

As with health equity concerns, socio-economic relationships have been strongly shaped by urbanization. The changing geographies of health and disease are seen in correlation with the intensification, extensification and differentiation of urban life worlds (94–96). Socioeconomic factors influence health outcomes and play a significant role shaping awareness, knowledge, behaviors and practices related to AMU and AMR. With the exception of AMR responses implemented before the launch of the GAP in

2015 (79,92), AMR approaches addressing socioeconomic factors are mostly guided by three of the five objectives advanced by the Global Action Plan on AMR, namely awareness raising, infection prevention initiatives, and ASP. Understanding how socioeconomic factors affect AMU and AMR is crucial for informing effective responses (97), yet AMR approaches across the selected studies do not explicitly consider the root causes underlying AMU and AMR acceleration.

AMR approaches addressing limited knowledge and awareness of AMU and AMR focus on activities related to education and training programs (85,86); hygiene and sanitation measures (46,48); waste management and disposal procedures (79,81); enhancing AMU, AMR and IPC policies, guidelines, regulatory and biosecurity measures (48,83,86,91); disease control and prevention (81,84,85); media campaigns (81,84,92); and awareness raising events such as conferences and meetings (86,48).

Studies mentioning economic factors influencing AMU and AMR focus on affordability and accessibility of antimicrobials. These approaches highlight the impact of poor regulations fueling indiscriminate AMU in humans-animals-agriculture, the use of low quality or counterfeit antimicrobials, and reduced profit from sales of antimicrobials (48,83,86,90,91). AMR approaches addressing these issues focus on activities related to reclassification and enhanced regulation of essential medicines (83,91); ASP targeting prescribers and consumers to improve AMU (86); and medicine quality assurance (48).

The importance of securing financial resources for development and implementation of AMR approaches was also a common theme across studies, with one study on OH operationalization noting that the priorities of international funding

partners may influence the nature of financial supports available and approaches adopted (85). Reliance on external funding is a common theme across studies discussing AMR strategies in LMICs (48,83–86,88,89,91), and some countries include identification of funding sources as part of their NAPs (81).

While AMR approaches did not consider the socioeconomic drivers of AMR beyond the factors indicated above, several authors highlight the importance of considering the underlying causes triggering AMU and driving AMR. Two studies highlight the need to expand the focus on awareness initiatives and link them to broader structural changes and the socioecological environment, namely existing water and sanitation programmes (46,48). Broader economic factors shaping AMR approaches are mentioned by authors that refer to high AMU in relation to increased domestic and international demand for consumption of animal products (83,84).

Another study highlights the reliance on donor support to improve WASH programmes included in existing IPC policies, but does not clarify the extent to which support was successfully leveraged (90). A study discussing the operationalization of OH in Nigeria highlights that indiscriminate AMU is intertwined in society's sociocultural fabric (86). Another discussing the operationalization of OH in Kenya noted that epidemiologists and social scientists were not included in the design of the AMR component of Kenya's OH response, recognizing that their exclusion could have significant impact on the delivery of OH programmes (85). Finally, a study discussing the implementation of India's NAP highlights that more should be done to recognize structural and socioecological dimensions that affect behavioral changes and antibiotic prescriptions (46).

Environmental Justice concerns

Environmental justice has been a main concern of UPE. Scholars in the field have, however, largely rejected liberal formulations of urban justice and have instead engaged in materialist discussions on justice more in line with UPE's focus on urban metabolism that includes relationships of production and consumption, labour and capital as conditions of just urban life (59,62,63). Enshrined in the new operational definition of OH, environmental justice involves addressing the unequal distribution of environmental risks and benefits among different communities. Despite its importance, the articles included found limited engagement of the environmental sector in AMR approaches. Weak engagement of the environmental sector in AMR responses was a common theme across selected studies (47,48,81,85,90,91), and may stem from the lack of concrete global policies and guidance informing approaches addressing environmental AMR until 2023 (83).

A range of activities may nonetheless contribute to environmental justice in varying degrees. Approaches seeking to standardize and harmonize environmental AMR surveillance activities and protocols support the generation of data and information that can reveal potential disparities in the distribution of risks and benefits (83), as long as surveillance sites are selected to ensure a balanced geographic, demographic and socioeconomic distribution (87).

Hygiene, sanitation, and environmentally friendly waste management procedures in healthcare and community settings potentially contribute to an equitable distribution of environmental gains (48,79,81,84), but poor infrastructure internal and external to healthcare settings may limit the effectiveness of these approaches (86). In addition, the

lack of explicit environmental justice considerations in AMR approaches likely influence the efficiency and equitable distribution of these environmental outcomes. In Tanzania, interventions strengthening public health systems were reported to focus disproportionately on urban areas (91), which can result in limited access to resources and infrastructure necessary to address AMR in remote areas.

Addressing the health implications and disparities for environmental AMR require approaches with broader focus on improving infrastructure for water and sanitation, prioritising IPC, and strengthening frontline healthcare workforce in rural and peri-urban settings to reduce reliance on antibiotics (46). Opportunities to consider environmental justice concerns would involve collaborative action to address pollution and waste management (84), and opportunities to link AMR approaches to other sanitation programs (46) and broader concerns such as SDG 6 - availability of safe water and sanitation (47). Table 1 (below) summarizes and organizes findings, mechanisms challenges and opportunities for enhancing enabling environments for OH-AMR governance approaches in terms of broader concerns, global health threats, socioeconomic factors, global governance frameworks, health equity and environmental justice concerns.

Table 4-1 Enablers for action through awareness-raising, advocacy, and adoption of socioecological approach to health and development

	Findings	Mechanism	Challenges	Opportunities
Broader concerns	Linking AMR approaches to broader concerns such as Global Health Security Agenda (47)	Guidelines and dedicated resources leveraged through existing OH intersectoral platforms (46,47,82)	Adequate resources and operating procedures (47)	Linking AMR approaches to SDGs and UHC plans (47)
Global Health threats	Integrating AMR approaches within other GH threats, such as infectious diseases, food safety issues, and environmental health hazards (80,83,84)	Integrate approaches within other GH threats through OH institutionalization (80,83,84)	Availability of documents outlining effective alignment of governance structures, policies, regulations and plans (46,47,82)	Safe delivery and neonatal healthcare, WASH infrastructure, IPC, healthcare workforce strengthening, diagnosis and surveillance interventions in primary care, national drug policies (46)
Socioeconomic factors	Recognize broader structural changes and socioecological environment in WASH programmes; recognize broader socioeconomic factors shaping AMU and AMR in awareness raising activities, IPC and ASP (GAP objectives) (46,48)	Inclusion of epidemiologists and social scientists in the design of OH-AMR approaches, recognize structural and socioecological dimensions affecting behavioral changes and antibiotic prescriptions (46)	Priorities of international funding partners may influence the nature of financial supports available and approaches adopted (84)	Donor support to improve WASH programs included in existing IPC policies (89)
Global Governance Frameworks	Play crucial - but understudied - role guiding, coordinating, and supporting AMR responses at national and international levels	International institutions and actors strongly aligned to OH guidelines and strategies	Financial support to AMR approaches by international actors or institutions may reflect donor priorities (84)	Diversify funding by framing AMR activities as related (eg value-added) to other OH and environmental priorities (48)
Health Equity	Engage diverse stakeholders in intersectoral OH platforms to consider the socioeconomic burden of AMR (88), and ensure equity in accessibility of healthcare services and antimicrobials (80)	Intersectoral OH platforms	Ensure interventions consider socioeconomic factors influencing marginalized groups' access to quality healthcare, water and sanitation facilities (85)	Support existing intersectoral OH platforms to explicitly consider intersections of health equity and sustainable development (47), and to support equitable health and environmental outcomes across targeted populations
Environmental Justice	Standardize and harmonize environmental AMR surveillance activities and protocols (82), and ensure surveillance sites consider balanced geographic, demographic and socioeconomic distribution (86)	AMR-OH surveillance systems	Poor surrounding infrastructure limiting effectiveness of WASH programs in healthcare and community settings (85)	Focus on improving WASH infrastructure, prioritising IC, and strengthening frontline healthcare workforce to reduce reliance on antibiotics (46)

4.6 Discussion

In an urbanized and interconnected world, UPE illuminates the interconnections among urban life, AMR risks, other global health threats and broader concerns affecting all life on earth and the systems upon which they depend. As a socio-ecological approach premised on sustainable nature-society relations, a UPE lens not only broadens the focus to include structural and local determinants shaping AMR risks, it also situates these risks in relation to global governance frameworks that ultimately shape AMR responses and their corresponding outcomes.

As a “new frame for understanding the relationship between cities and the environment in contemporary urban policy” (98), UPE is mobilized as both an epistemological approach and a guide to practical politics of sustainability and human-nature relationships, contributing to an understanding of how AMR and other systemic threats may be confronted in policy and practice (53,60). Mobilizing a UPE lens on OH-AMR approaches can situate these responses within broader dimensions, while exploring under-exposed societal relations with nature beneath and beyond societal angles that are often entrenched within pre-conceived institutional and political perspectives.

Our analysis of the extent to which the included articles situate OH-AMR approaches along the 5 dimensions varies, revealing insights from authors that recognize opportunities and limitations to generate health and environmental gains for targeted populations. While our synthesis situates OH-AMR approaches within most of the dimensions outlined, the influence of global governance frameworks - of UN

agencies and their counterparts – is by far the most underexplored dimension with perhaps the highest transformative potential.

In considering the role of global governance frameworks in guiding coordination and institutionalization of OH AMR approaches at the state level, more research exploring the feasibility and capacity of global institutions and actors to expand their OH-AMR governance guidelines to directly contribute to health equity and environmental gains, as enshrined in the operational definition of OH would be beneficial. Synthesis of the included studies also suggests that more research is needed to consider OH-AMR approaches that link to broader concerns such as SDGs or UHC (47), integrated to other global health responses or policies such as infectious disease programs (46) or environmental policies (99–101), recognize broader socioeconomic factors shaping AMU and accelerating AMR (46,48), and consider health equity and environmental justice concerns influencing AMR risks (81,83,86,87,89).

Recasting and situating OH-AMR approaches within the dimensions typically analysed under a UPE lens - broader concerns, other global health threats at the human-animal-environment interface, socioeconomic factors, health equity and environmental justice concerns – would reveal connections between AMR strategies and these dimensions, informing a rationale that demonstrates how governance implementation challenges– such as externalized costs of AMR risks, biomedical and biosecurity framings of AMR responses, and lack of ethical clarity informing AMR response – may be confronted by an adjustment of existing OH-AMR governance approaches.

Much like OH-AMR responses that reproduce northern-dominated framings and market integration efforts (2,12,15) whose lack of clarity conceals value systems and ethical considerations informing the design of these responses (45), depoliticized notions of urbanization processes and forms reproduce interventions informed by an exclusionary global history of environmental degradation, dispossession and uneven capitalist development (55,56). By engaging with UPE as a socioecological transformation deeply connected to the natural “One Health” world (67), a UPE of AMR assessment aligns with calls to rescale socio-ecological governance arrangements by better taking societal relations with nature into account (55,62).

Here, UPE theory contributes to a vision of planetary urbanization premised on calls to protect the global commons which can inform OH-AMR governance arrangements focused on a renegotiation of ecological, institutional and political perspectives through intersectoral governance that addresses broader structural changes and socioeconomic factors shaping AMU and AMR (102–104).

Engaging communities, civil society and other non-state actors in clarifying the factors that produce the vulnerabilities accelerating AMR would inform interventions that are locally relevant, responsive and “bioecological” (95,105). Intersectoral governance platforms and awareness programs could integrate health equity and environmental justice concerns through representation of marginalized communities (89), and equitable distribution of environmental and health gains which may ultimately reduce antibiotic dependency (46), rather than focusing solely on equitable access to healthcare and effective antimicrobial treatments in ASP (81,89).

Conceptualizations of planetary urbanization processes and forms consider connections between infrastructure networks, global capital flows, resource distribution, urban expansion/concentration and environmental degradation in the face of climate crisis, emerging pandemic and AMR threats (2,6,23,50,53,60,65,66,94,96,99,106,107). Institutionalization of OH-AMR governance frameworks that seek to address the *externalities* of AM misuse through integration with responses to other global health threats (81,84,85) may draw on scholarship that theorizes governance practices in the context of neoliberal organization of resources, practices of sustainability, circularity or resilience that explore the commodification and privatization of structural determinants, and consequently rescale governance arrangements that situate AMR risks in relation to their structural dimensions (23,108), broader concerns (47), infectious diseases (84,85), food safety issues (81,84,85), or environmental hazards (84,85).

Rather than being informed by rationales premised on technical or market integration efforts (2), OH-AMR governance responses guided by socioecological approaches to health and development (46,48) such as an eco-scalar fix – understood here as a strategy of internalizing socio-environmental externalities through the construction of (purportedly “natural”) ecological scales (53) – necessarily situate OH-AMR responses within broader concerns and responses to other global health threats (99–101,109).

As AMU became interwoven with the dynamics of modern urban societies and economies (12,22,72), the acceleration of AMR in the environment has also become interlaced with extended urbanizations and the anthropogenic pressures that shape urban realities, obscure inequalities and environmental hazards that produce AMR

hotspots (5,6,38,70). Rendering extended urbanizations as global scale forms and processes that incorporate human-nature relations reveals the often underexposed interdependencies between ecologies and the urban as integral and mutually constitutive parts of extended urbanizations that are also influenced by northern dominated biosecurity and biomedical framings that have drawn attention to failures regarding the use and prescription of antibiotics (15,110).

Tackling the complexity of AMR hotspots in a predominantly urbanized world would entail future research considering them as extended urbanization processes and forms subject to market pressures, international competition, and hierarchies of global economies from the Global North (23,68). More research is also needed to consider the feasibility and relevance of OH-AMR approaches that are linked to broader concerns such as SDGs or UHC (47), integrated to other global health responses or policies such as infectious disease programs (46) or environmental policies (99–101), recognize broader socioeconomic factors shaping AMU and accelerating AMR (46,48), and consider health equity and environmental justice concerns influencing AMR risks (81,83,86,87,89).

4.7 Conclusion

Informed by UPE lens, this synthesis sheds light on the interconnections between urbanization processes and forms, AMR risks, global health threats, and the broader ecological challenges that impact our planet. By adopting a socio-ecological perspective within a UPE framework, the synthesis not only expands our understanding of the structural and local factors influencing AMR risks, but also situates these risks

within the context of global governance frameworks that ultimately shape responses and outcomes.

As a practical guide for sustainable policies, UPE emphasizes the need for a holistic approach to confront not only AMR but also other systemic threats. Our analysis highlights the importance of examining underexplored societal relationships with nature, challenging us to consider the ethical dimensions, the global history of environmental degradation, uneven development, dispossession, and the impact of market driven-interventions on AMR risks. The interconnectedness of urbanization, global capital flows, resource distribution, and environmental degradation may contribute to the complex landscape of AMR. As such, further research viewing AMR hotspots as extended urbanization processes influenced by market pressures and global economic hierarchies is warranted.

Within the five identified dimensions, the role and transformative potential of global governance frameworks remains significantly underexplored. Further research into the capacity of global institutions and actors to contribute to health equity and environmental justice gains would clarify their strategic role. By situating OH-AMR responses within a UPE lens, we may gain valuable insights into the political, economic, and ecological aspects that influence AMR governance approaches.

Engaging communities, civil society, and non-state actors in shaping interventions that consider local vulnerabilities and ecological aspects may promote resilient bioecological responses that extend beyond equitable access to healthcare and antimicrobial treatments. This synthesis also underscores the necessity of linking OH-AMR approaches to broader concerns such as Sustainable Development Goals (SDGs)

and Universal Health Coverage (UHC), integrating them into existing global health responses, considering socioeconomic factors, and addressing health equity and environmental justice concerns.

In summary, this CIS deepens our understanding of the multifaceted challenges posed by AMR, calling for a critical evaluation of existing governance approaches while offering a compelling case for the adoption of a UPE lens to inform future efforts in addressing AMR and related global health challenges.

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Chapter 5 – Integrated Discussion

5.1 Introduction

Infectious disease prevention in wildlife trade and approaches addressing antimicrobial resistance (AMR) share similar governance challenges. The main goal of this dissertation was to address the governance of infectious diseases prevention and AMR by gaining an understanding of the governance models that adopt a One Health (OH) approach to address the governance of AMR and infectious diseases in the wildlife trade. To achieve this goal, this dissertation focuses on three specific objectives that correspond to the three manuscripts comprising this dissertation.

Chapter 2 describes a scoping review whose aim is to identify and describe regulatory approaches governing wild animal markets, including their wildlife supply chains, to understand current regulatory frameworks governing wildlife trade as an important step for effective zoonotic spillover prevention measures at the human-animal-environmental interface.

Chapter 3 integrates Urban Political Ecology (UPE) as a theory for identifying under-exposed urban dimensions of AMR to offer theoretical depth to explore the sociopolitical ecologies of AMR, and to inform governance strategies addressing the upstream structural drivers of AMR and interconnected environmental threats.

Chapter 4 describes a critical interpretive synthesis to clarify the extent to which scientific literature has situated OH-AMR governance responses in relation to the five socioecological UPE dimensions affecting the outcomes of AMR interventions.

5.2 Summary of research findings

Before focusing on the overall significance and contributions of this dissertation, this section presents a summary of key research findings and discussions informing the integrated discussion.

Chapter 2 - Preventing zoonotic spillover and infection transmission through regulatory frameworks governing wildlife trade: a scoping review

Reducing the probability of spillover events is key to prevent future pandemics. Measures involve reducing the human footprint in natural systems – including but not limited to wildlife trade (1,2) – and emphasizing the inclusion and separate funding of regulations and measures that address ecology, conservation, and wildlife biology related to spillover prevention in multilateral cooperation fora (1,3,4). Spillover prevention measures also involve the effective implementation of regulatory approaches governing wildlife trade, including their wildlife supply chains.

Research findings suggest that one of the biggest challenges for governing wildlife trade is the ambiguity of regulation within and across countries. This also applies to regulatory approaches governing exotic pet trade, and regulatory approaches governing wildlife trade for use in traditional medicine.

By setting international standards to guide national practices, global organizations largely inform governance, legislation, and information sharing concerning the prevention of zoonotic infection. Interestingly, findings indicate that a mandate to prevent zoonotic spillover was not always explicitly the focus on these organizations, whose regulatory authority is also fragmented and spread throughout a few organizations.

While regulatory approaches would contribute to zoonotic spillover prevention, it would do so indirectly through other pathways. In this regard, the complex regulatory environment described in our findings seem to lack a broader intersectoral approach linking wildlife trade to the complex socioecological interactions that produce the vulnerable interfaces where zoonotic spillover occurs (5). Hence, our main recommendation is for future research mobilizing a OH approach to improve information sharing, intersectoral governance and policy coordination that contributes to a better understanding of the role of global and national organizations in preventing zoonotic spillover and transmission.

However, as discussed in Chapter 3, the adoption of OH approaches to address governance fragmentation and enhance intersectoral coordination of complex global health responses also present challenges. Chapter 3 integrates UPE as a critical urban lens to explore under-exposed dimensions of AMR, and to inform strategies addressing these dimensions and implementation challenges.

Chapter 3 - The Urban Political Ecology of Antimicrobial Resistance: a critical lens on integrative governance

The rise of AMR represents not only a threat to human-animal-ecosystems health, but also to the fabric of society, modernity and the systems upon which it depends (6). Without antimicrobials, such as antibiotics, antivirals, or antifungals, the viability of food systems, agriculture, farming, healthcare, water, hygiene, and sanitation systems would be threatened.

Even though AMR is a natural mechanism, it can be accelerated by antimicrobial use in humans, animals and the environment, and anthropogenic activities affecting

microbial organisms found in marine, freshwater and terrestrial ecosystems, wastewater treatment plants, agricultural sites, aquaculture operations and hospitals (7–11).

Despite progress in the implementation of OH-AMR governance approaches (12–15), and growing recognition of the co-benefits generated by measures jointly addressing human-animal-environmental health (16–19), effective institutionalization of these governance approaches remains a challenge. Common barriers to effective institutionalization include the effects of market failure that enable the consequences of antimicrobial overuse to be externalized to other sectors, thereby inadvertently creating its structural drivers (20,21); institutionalized AMR governance responses characterized as fragmented, lacking in OH intersectoral coordination (22–25); OH-AMR responses that tend to reproduce Northern-dominated biosecurity and biomedical innovation framings (6,26); and triumphalist global health security approaches premised on technical and market integration efforts (27), whose lack of clarity conceals value systems and ethical considerations informing the conceptualization and design of OH-AMR governance responses (28).

Adapting the theoretical framework developed by Ali et al. and others to propose that AMR is not only determined through biophysical processes, but also constructed out of a particular set of social and spatial relations which are mediated through the landscape (29), chapter 3 draws on the work of several UPE scholars to inform socioecological analysis of AMR, its interconnected threats, as well as analysis of OH governance responses addressing these threats.

Furthermore, chapter 3 integrates UPE as a theory for identifying under-exposed urban dimensions of AMR, and for informing a strategic approach to address upstream

structural drivers of antimicrobial-environmental threats. Drawing on a summary of UPE contributions as a basis for the development of a conceptual approach to UPE of AMR (30), chapter 3 identifies four main contributions that inform enhanced OH-AMR governance approaches.

The first set of contributions are based on a call to redress societal relations with nature by (i) rethinking human and more-than-human relationalities of AMR, and by (ii) exploring situated and extended urbanizations affecting AMR. The second set of contributions are based on a call to rescale socioecological governance arrangements by (iii) addressing the externalities of AMR, and by (iv) drawing on planetary urbanization frameworks that include calls for collective uses and the common good.

Situating AMR within a UPE lens, chapter 3 also provides a theory and rationale for the development of shared OH governance approaches addressing AMR and other interconnected threats, such as climate change. As a “new frame for understanding the relationship between cities and the environment in contemporary urban policy” (31), integrating UPE as both an epistemological frame and a guide to practical politics of sustainability and human-nature relationships contributes an understanding of how AMR and other systemic threats may be confronted in policy and practice.

Chapter 4 – A Critical Interpretive Synthesis of One Health governance of antimicrobial resistance: an Urban Political Ecology lens reveals under exposed dimensions

Chapter 4 describes a critical interpretive synthesis (CIS) whose aim is to clarify the extent to which scientific literature has situated OH-AMR governance responses in relation to the five identified socioecological dimensions affecting the outcomes of AMR

interventions. Informed by the UPE lens developed in Chapter 3, the CIS of OH-AMR governance approaches sheds light on how responses to this global health threat address AMR risks in relation to interconnections between urbanization, other global health threats such as infectious diseases or food safety issues, global governance frameworks and the broader health equity and ecological challenges that impact our planet.

Drawing on a UPE lens that can be mobilized as a practical guide for sustainable policies, chapter 4 offers a compelling case for the adoption of socioecological frameworks to evaluate integrative governance approaches, and to inform measures to address OH governance implementation challenges such as fragmentation, externalization of costs, northern-dominated biosecurity and biomedical framings that ignore the complexities of AMR, and triumphalist approaches premised on technical and market integration efforts (27), whose lack of clarity conceals value systems and ethical considerations informing the conceptualization and design of OH-AMR governance responses (28).

5.3 Overall significance of manuscripts

The challenges associated with wildlife trade, exotic pet trade, and traditional medicine have direct implications for public health. By shedding light on the fragmentation of authority and the ambiguity of regulations in this governance space, this research underscores the importance of harmonizing international standards and cooperation, contributing to our understanding of how zoonotic spillover events can be prevented through effective regulation.

An underlying theme across Chapter 2 is the need to view wildlife trade governance within the broader context of socioecological interactions, which is a crucial insight for preventing future pandemics. The call for future research adopting a OH approach to improve information sharing, intersectoral governance and policy coordination may contribute to a better understanding of the role of actors and institutions in preventing zoonotic spillover and transmission.

The integration of UPE scholarship within OH approaches also offers a unique perspective on AMR and governance approaches. By identifying under-exposed urban dimensions of AMR and its upstream structural drivers, it provides a theoretical framework for integrative governance approaches that address not only AMR, but also its interconnected threats, which is vital for more sustainable and effective policies.

The practical implications of the UPE of AMR for policy and governance are elaborated and discussed in the critical interpretive synthesis (CIS) of OH-AMR governance approaches (Chapter 4). The mobilization of a UPE lens to explore peer-reviewed literature discussing the implementation of OH-AMR approaches clarifies how responses to AMR are situated within socioecological dimensions including urbanization processes, global health threats, global governance frameworks, environmental justice and health equity concerns.

One of the key takeaways of this CIS is the crucial - but understudied - role of global governance frameworks guiding, coordinating and supporting integrative governance responses at national and international levels. Future research exploring the feasibility and capacity of these institutions and actors to expand their OH-AMR governance approaches to directly contribute to health equity and environmental gains -

as enshrined in the operational definition of OH - may inform more holistic, sustainable and comprehensive responses.

In summary, this dissertation contributes to our knowledge of research and governance gaps in zoonotic spillover prevention in the wildlife trade and AMR, as well as on possible integrative governance models. Collectively, this dissertation deepens our understanding of the inherent complexity of threats at human-animal-environmental interfaces, emphasizing the need for holistic and intersectoral approaches, by offering insights into the complexities of wildlife trade regulations, the social dimensions of AMR and the role of global governance frameworks shaping outcomes of AMR responses. Importantly, this dissertation calls for renewed efforts to mobilize critical urban lens in global health research and practice, which is particularly relevant in the current context of preventing future pandemics and safeguarding public health in an increasingly more interconnected world.

5.4 Implications for policymakers

Policymakers must navigate complex regulatory and governance environments to comprehensively address challenges posed by wildlife trade and AMR. Some of the key insights generated by this dissertation that may be relevant for policymakers are listed below.

Wildlife Trade Governance

- Temporal mismatch across wildlife trade regulatory approaches: policymakers should develop measures to address the temporal mismatch between the adoption of protected species lists and domestic regulations. Expanded mandates to organizations focused on developing precautionary interim risk management

approaches, such as adopting updated Convention on International Trade in Endangered Species lists while domestic regulations catch up, may be necessary to prevent illegal wildlife trade and mitigate the risks of zoonotic spillover.

- Coordination of national and global institutions: policymakers should strengthen information sharing and capacity building to support better coordination and collaboration between national and global institutions and actors.
- Adoption of OH approach: policymakers should consider adopting a OH approach to address fragmentation, improve intersectoral governance and policy coordination. This approach can galvanize efforts, enhance the understanding of the roles of global and national organizations in preventing zoonotic spillover and transmission, and can situate zoonotic spillover in the wildlife trade within broader socioecological determinants affecting spillover risks.

AMR Governance

Recognizing the interconnectedness of AMR within broader concerns is crucial for shaping effective policies and practices in an increasingly urbanized and interconnected world.

- Integration of AM-Environmental stewardship: policymakers should consider integrating AMR governance approaches within environmental stewardship measures. Recognizing the interconnections between AMR and environmental issues can lead to synergistic solutions. This integration can generate co-benefits for human and planetary health, aligning with broader goals such as climate change mitigation and sustainable production and consumption patterns.

- Health Equity and Environmental Justice considerations: policymakers should acknowledge the inequities associated with AMR, including its links to climate change, environmental degradation, the Sustainable Development Goals and other global agendas. Addressing these inequities through shared governance approaches should be a central consideration in policy design, coordination and implementation.
- Broader dimensions of AMR: policymakers should adopt a broader approach to frame and address AMR, recognizing the interconnectedness of AMR with broader ecological and societal challenges. The application of a UPE lens challenges policymakers to consider the ethical dimensions of AMR (32), the impact of biosecurity measures and market-driven interventions on AMR risks, as well as the impacts of environmental degradation, dispossession and uneven development in shaping AMR risks. Viewing AMR hotspots as extended urbanization processes influenced by market pressures and global economic hierarchies sheds light on the structural determinants and challenge policymakers to reconsider local and structural socio-economic factors that influence AMR risks and shape policy outcomes.
- The underexplored role of global governance frameworks: policymakers should recognize the transformative potential of global governance frameworks in addressing AMR. While further research is needed to understand their capacity to contribute to health equity and environmental justice, policymakers should explore ways to support global institutions and actors to integrate AMR responses into broader policies that address the complex interconnections of AMR.
- Mobilization of integrative AMR governance approaches: policymakers should evaluate AMR governance approaches through critical socioecological lens that

foster more comprehensive and interdisciplinary socioecological perspectives on AMR governance, adapting approaches to align with the complexities of AMR and its interconnected challenges.

5.5 Points for future research

A UPE approach suggests, first, that measures to address AMR must take into account the structural and socioecological forces beyond the control of individuals that impact global health equity (33–36). Second, structural interventions to address AMR must be integrated within measures to reduce global inequities arising from the commodification of health determinants and the privatization of commons resources management that affect AMR risks.

Critical political economy approaches to health inequalities focus on the structural determinants of human health. These approaches are well positioned to inform strategies that address AMR while redressing societal relations with nature. Critical political economists have examined inequities arising from the commodification of health determinants, the privatization of commons resource management, and the political means and equitable impact of distributive policies on different regions and societies (37–39). Lessons learned (40) include the extent to which distributive policies affect health inequalities and emphasize the importance of equity and justice.

Future research should consider the adoption of similar political economy perspectives to inform integrative governance approaches. As systemic threats and the socioecological environments in which they interconnect evolve, further research exploring the mobilization of UPE to foster similar perspectives may inform the influence of distributive policies in addressing AMR.

5.6 Limitations

The Scoping Review in Chapter 2 included only published studies and publication bias is a possible limitation. We addressed this by having two reviewers reach consensus on articles to be included and the analysis of thematic content. The grey literature dealing with different aspects of wildlife trade regulatory frameworks may refer to additional organizations and institutionalized regulatory approaches.

A possible limitation is that our search strategy did not differentiate between traditional Chinese medicine and traditional medicine. In addition, our lack of findings regarding regulation of traditional medicine may reflect a limitation of our search strategy of including only articles written in English, or it may suggest that animals and animal products used in traditional medicine are not distinguished within international regulation, nor regulated towards the prevention of zoonotic spillover.

As the goal of Chapter 3 is to adopt a transdisciplinary approach that incorporates and melds UPE scholarship with OH to highlight limitations in AMR governance and generate ideas across disciplines to address a gap in the literature, an in-depth engagement with UPE literature is beyond the scope of this chapter.

The broad range of UPE also limited a systematic analysis of the available literature. This was addressed by an introductory juxtaposition of recent articles summarizing main contributions to UPE scholarship, as they relate to the theory and practice of AMR governance. Differences in how UPE and health scholarship engage with concepts and core arguments was accounted and addressed by attempting to strike a balance between article depth and length.

The CIS in Chapter 4 only considered peer-reviewed literature discussing governance arrangements. While the inclusion criteria of Chapter 4 ensured that only peer-reviewed discussions about arrangements being implemented were captured by our CIS, this criteria for inclusion limited the sample size by excluding grey literature documenting implementation of these approaches, therefore potentially missing relevant insights and lessons learned that could contribute to a more robust sample. The five socioecological dimensions presented in this manuscript - as well as their relative weight and importance - are also based on the proposed theoretical framework and emphasis placed by the authors of the CIS, and not necessarily by authors of selected studies. The CIS sheds light on the importance to deploy a UPE lens to deepens our understanding of the challenges posed by AMR, and a finer understanding of how to incorporate and operationalize AMR responses informed by a UPE lens is beyond the scope of this manuscript, even though it is a necessary step towards the adoption of a UPE lens to enhance existing OH-AMR governance approaches.

5.7 Conclusion

This research highlights the critical importance of adopting a holistic approach to address complex global health challenges, particularly in the context of zoonotic spillover prevention and AMR.

Reducing the probability of spillover events is paramount in preventing future epidemics and pandemics. This necessitates measures to diminish the human impact on natural systems, including wildlife trade, while emphasizing the inclusion and dedicated funding for ecology, conservation, and wildlife biology in spillover prevention efforts. Additionally, addressing regulatory fragmentation through better coordination

and harmonization of frameworks with considerations for livelihoods and food security may ultimately reduce the risk of zoonotic spillover and transmission.

Similarly, global governance of AMR remains fragmented and lacks intersectoral coordination. Viewing this issue through a UPE lens illuminates the interconnectedness and socioecological dimensions of AMR. A UPE perspective offers a framework to evaluate and address current and underexposed dimensions of AMR.

Furthermore, the need for socioecological perspectives on AMR is highlighted through an analysis that sheds light on the important – but underexposed – UPE dimensions of AMR, challenging us to consider the ethical dimensions, the global history of environmental degradation, uneven development, dispossession, and the impact of biosecurity- and market driven-interventions on AMR risks. UPE of AMR not only deepens our understanding of local and structural factors influencing AMR risks but also situates them within the context of global governance frameworks shaping governance responses and their outcomes.

A UPE lens may be used as a practical guide for sustainable policies, encouraging a holistic approach not only for AMR but also for other systemic threats. In conclusion, this dissertation calls for a critical evaluation of existing OH governance approaches and advocates for the adoption of a UPE lens to inform future efforts in addressing not only AMR but also related global health challenges.

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Supplemental Information 1 – Chapter 2 Search Strategy

Search Question		
1.	Search Question	RQ1 What are the different regulatory approaches governing wild animal markets, exotic animals, traditional medicine, and exotic pets described in the published literature
Main concepts		
2.	Concepts	<ol style="list-style-type: none"> 1. Regulatory approaches 2. Wild animal markets
3.	Search Terms	
	Concept 1	Concept 2
AND	Regulatory approaches	Wild animal markets, traditional medicine, and exotic pets
OR	((Accountability OR Agreement* OR Ban* OR Convention* OR Governance OR Guideline* OR Law* OR Legal OR Monitor* OR Polic* OR Regime* OR Regulat* OR Rule* OR Standard* OR Surveillance OR Treat*) adj1 Trade).ab,ti.	(Exotic animal* OR Exotic Pet* OR Traditional Medicine).ab,ti. OR ((Bushmeat OR Illegal OR Live OR Meat OR Wet OR Wild OR Wildlife) adj2 Market*).ab,ti.

Search Question				
1.	Search Question	RQ2 What are the different regulatory approaches governing importation of wild animals across international borders described in the published literature?		
Main concepts				
2.	Concepts	1. Regulatory approaches 2. Importation 3. Wild animals 4. International Borders		
3.	Search Terms			
AND	Concept 1	Concept 2	Concept 3	Concept 4
	Regulatory approaches	Importation	Wild animals	International Borders
OR	("Convention on International Trade in Endangered Species of Wild Fauna and Flora" or "Third-party certificat*" or "Memorandum of Understanding" or "Food and Agriculture Organization" or "World Health Organization" or "World Food Program" or "World Organisation for Animal Health").ab,ti. ((Accountability OR Agreement* OR Convention* OR Governance OR Guideline* OR Law* OR Legal OR Monitor* OR Polic* OR Regime* OR Regulat* OR Rule* OR Standard* OR Surveillance OR Treat*) adj1 Trade).ab,ti.	(Export* OR Importat* OR Smug* OR Traffick*).ab,ti.	(Companion Animal* OR Exotic Animal* OR Exotic Pet* OR Farm Animal* OR Feral Animal* OR Global wildlife OR Wildlife OR Nondomestic Animal* OR Nondomesticated Animal* OR Stray Animal* OR Wild Animal* OR Wildlife).ab,ti.	(Across OR Countr* OR International OR Regional OR State OR Supranational OR Supranational).ab,ti.

Search Question					
1.	Search Question	RQ3 What are the roles of national and global-level institutions in the prevention of local zoonotic spillover and infection transmission described in the published literature on regulatory approaches governing wild animal markets?			
Main concepts					
2.	Concepts	<ol style="list-style-type: none"> 1. local, national and global (institutions) 2. prevention 3. zoonotic 4. spillover 5. regulatory approaches 			
3.	Search Terms				
AND	Concept 1	Concept 2	Concept 3	Concept 4	
	National and Global (institutions)	prevention	zoonotic	Spillover	Regulatory approaches
OR	(Cit* OR Count* OR Federal OR Global OR International OR Local OR Metropolitan OR Municipal OR National OR Regional OR State* OR Supranational OR Supra-national).ab,ti.	(Control OR Emergence* OR Prevention).ab,ti.	(Zoono* OR Wildlife).ab,ti.	(Infection* OR Disease* OR Spillover OR Transmission).ab,ti.	((Accountability OR Agreement* OR Convention* OR Governance OR Guideline* OR Law* OR Legal OR Monitor* OR Polic* OR Regime* OR Regulat* OR Rule* OR Standard* OR Surveillance OR Treat*) adj1 Trade).ab,ti.

Supplemental Information 2 – Chapter 2 Study Characteristics

#	Author	Title/Year	Type of Publication	Study Objective(s)	Study Design and/or Methodological Approach	Key Results	Conclusions
1	Borzée et al	Using the 2020 global pandemic as a springboard to highlight the need for amphibian conservation in eastern Asia. 2021.	Review	Argues for restrictions to amphibian farming; regulation of the amphibian pet trade; and expansion of the wildlife trade ban to decrease the risk of zoonotic transmission and protect the environment.	Qualitative design	Completely ban the farming of non-native amphibian species, especially when there is a high potential for feral populations to become established invasive species. Regulate movement of species that can spread pathogens through the global pet trade. Expand the wildlife trade ban to limit the wildlife-human-pet interface and non-sustainable farming practices.	Future Needs: Certification system and fraud prevention mechanisms. Align regulations with species extinction risk and specific trade threats. Set quotas; enforce CITES procedures; improve reporting and training of national enforcement bodies. Future Research: Amphibian identification systems to enable certification. Recommendation: Measures that tailor regulations to prevent future zoonotic transmission and conservation risks.
2	Cooper et al	International regulation of wildlife trade: Relevant legislation and organisations. 2022.	Review	To clarify and examines the areas, level, and content of the legislation that affect international wildlife trade; and their roles and influence on the trade.	Qualitative design	International legislation for wildlife trade involves (1) animal health; (2) animal welfare; and (3) international movement of endangered species. There are also policy and guidance documents for wildlife conservation within the wildlife trade or movement of wildlife.	Recommendations: Those who deal with international trade in wildlife (e.g. veterinarians) need an understanding of the relevant legislation (e.g. animal health, CITES provisions) for a successful and responsible management of wildlife movement. The veterinary community should be better utilized as the profession can significantly contribute to wildlife conservation and the prevention of zoonotic transmission.
3	Kahn et al	The role of the World Trade Organization and the 'three sisters' (the World Organisation for Animal Health, the International Plant Protection Convention and the Codex Alimentarius Commission) in the control of invasive alien species and the	Article	To describe the role and responsibilities of the World Organisation for Animal Health, the International Plant Protection Convention, the Codex Alimentarius Commission, and the World Trade Organization Sanitary and Phytosanitary Committee in relation to the control of invasive alien species and the preservation of biodiversity.	Qualitative design	The World Organisation for Animal Health mandate does not specifically address the impact that a species may have on the biodiversity of an importing country. The International Plant Protection Convention mandate and program is mainly concerned with invasive alien species and biodiversity, whereas the Codex Alimentarius Commission is not involved in this field.	A future expansion of the World Organisation for Animal Health mandate would need to be decided by its Members and expertise and financial resources would be required.

#	Author	Title/Year	Type of Publication	Study Objective(s)	Study Design and/or Methodological Approach	Key Results	Conclusions
		preservation of biodiversity. 2010.				The World Organisation for Animal Health may serve a more direct role regarding invasive alien species and biodiversity as it relates to protecting animal health if a broad interpretation were applied to the World Trade Organization Sanitary and Phytosanitary Agreement.	
4	Korwin et al	Verification of Legal Acquisition under the CITES Convention: The Need for Guidance on the Scope of Legality. 2019.	Article	To explore what laws are part of the protection of flora and fauna, i.e., the scope of legality of legal acquisition verifications under CITES.	Qualitative design	Although a CITES permit has the connotation of a wildlife shipment being legal, many CITES parties continue to not comply. Thus, developing guidance on how to ensure consistency in verifying legal acquisition becomes important to minimizing illegal wildlife trade, zoonotic transmission, and promoting conservation. A broader understanding of the legal acquisition finding will (1) draw from a body of legislation that is broader than that applicable to the sector; (2) address sustainability through harvesting rights, biodiversity conservation, and third-party legal rights concerning resource use; and (3) be collaborative.	Future Needs: Develop further guidance on how to define the scope of legality through an international workshop or national, multi-stakeholder processes.
5	Neuwirth et al	The Regulation of Trade and Public Health in Asia-Pacific: A Case For "Inter-Regime Regulatory Co-opetition". 20215.	Article	To describe the major international legal regimes relevant for the global governance of public health and how to improve the existing global health governance framework.	Qualitative design	Developing a global health governance framework involves integrating several international legal regimes involved in health, including 1) international trade law, 2) international intellectual property law, 3) international competition law, 4) international private law, and 5) international health law. The international legal order governing global health issues is largely fragmented and lacks coordination between various legal regimes (e.g. legal regimes have differing levels of national harmonization). Inter-regime regulatory cooperation	Difficulty in legally defining concepts related to health, (e.g. traditional medicine): definition would only consider part of the larger continuum of perspectives and aspects that constitute health. Global health governance will be determined by how Asian policy-makers interact with Western governments.

#	Author	Title/Year	Type of Publication	Study Objective(s)	Study Design and/or Methodological Approach	Key Results	Conclusions
						is an approach which simultaneously combines regulatory cooperation and competition between governmental and non-governmental actors and processes at both the national and international level, and between different international legal regimes as well.	
6	Pires et al	Preventing Wildlife Crimes: Solutions That Can Overcome the 'Tragedy of the Commons'. 2011.	Review	To examine how alternative methods in reducing poaching can be applied to other wildlife crimes using the illegal parrot trade, the market for wildlife skins, and over-fishing as case studies to reduce the poaching and exploitation of species.	Qualitative design	National and international approaches to wildlife trade regulation may ignore the impacts on poor rural communities and attempts to conserve wildlife. Situational crime prevention may prevent the overexploitation of wildlife while promoting sustainable economic development. Situational crime prevention involves increasing the effort and risks, and changing the contextual environment to prevent overexploitation of wildlife. Situational crime prevention involves increasing the effort and risks, and changing the contextual environment to prevent overexploitation of wildlife. Responses are specific to the context (i.e. species, settings, surrounding socioeconomic and cultural contexts).	<u>Research Gap:</u> The effectiveness of regulating trade versus banning trade, with which species and in which geographic regions. <u>Future Needs:</u> Need for political will and support of local stakeholders. Need to expand the definition of wildlife crime to include practices that harm wildlife, yet are legal (e.g. deforestation). Need to redefine the success of policies to address wildlife crimes.
7	Poissonnier et al	The role of the OIE in information exchange and the control of animal diseases, including zoonoses. 2013.	Review	To examine the role of the World Organization for Animal Health regarding information exchange and the control of animal diseases, including zoonoses.	Qualitative design	The OIE is a reference organisation for 1) scientific information and expertise on animal diseases and zoonoses; 2) international trade and the control of animal diseases and zoonoses; and 3) information-sharing among Member Countries on animal diseases and zoonoses through its a) standards and expertise; b) reference centres; c) World Animal Health Information System and Database; and d)	The World Organization for Animal Health's role in promoting transparent exchanges of animal health and scientific information among countries is vital for controlling animal diseases and zoonoses. Communication between livestock producers, private veterinarians, and public veterinarians is necessary, as well as between countries and with private international organizations.

#	Author	Title/Year	Type of Publication	Study Objective(s)	Study Design and/or Methodological Approach	Key Results	Conclusions
						cooperation and collaboration with other international organisations.	
8	Reeve, R.	The convention on international trade in endangered species of Wild Fauna and Flora (CITES). 2007.	Chapter from edited book: Making Treaties Work: Human Rights, Environment and Arms Control (pp. 134-160).	To discuss the legal basis for compliance and enforcement within CITES and the effectiveness of these mechanisms.	Qualitative design	Trade sanctions and the threat of trade sanctions provoke compliance and indirectly capacity building.	CITES is plagued by a lack of financial resources. Trade sanctions continues to face some resistance and fear from parties, but is increasingly used with opportunities for further mainstreaming and acceptance.
9	Thiermann, A. B.	International standards in mitigating trade risks. 2011.	Article	To describe the role of the World Organization for Animal Health to prevent the spread of animal diseases, including zoonoses, in international trade.	Qualitative design	World Organization for Animal Health provides international standards in mitigating trade risks through its work in best practices; capacity-building; collaboration and promotion of public-private partnerships; competence and credibility assurance; good governance; and dispute mediation.	<u>Future Needs:</u> Additional science-based international standards or an improved dispute resolution mechanism are not needed, but rather, a global commitment, and the necessary political will, to adhere fully to agreed international public trade standards.
10	Toland et al	Turning Negatives into Positives for Pet Trading and Keeping: A Review of Positive Lists. 2020.	Article	To review the implementation of positive lists, its issues, and functions to regulate the exotic pet trade.	Qualitative design	Positive lists do not include species unless rigorous scientific assessment has shown them to be suitable to be traded and kept as pets for reasons including public health and safety, animal welfare, conservation, environmental protection, and invasive species risk. Positive lists aid species conservation, protect biodiversity, safeguard animal welfare, and prevent zoonoses and other infections. Benefits: Simple; easy to enforce; provides clarity; efficient use of limited resources.	<u>Future Research:</u> Impact assessment of positive lists in terms of preventing diverse present and future harms. <u>Future Needs:</u> Regulate exotic pet ownership to prevent zoonotic spillover potential among other reasons (e.g. public health and safety, species conservation, environmental preservation; animal welfare; and invasive species risk)
11	Vallat et al	Office of International Epizootics: Mission, Organization and Animal Health Code. 2011.	Chapter in edited book: Encyclopedia of Dairy Sciences: Second Edition (pp. 1-8).	To describe the history, structure, mandate, activities, and major publications of the World Organization for Animal Health to determine its efforts and importance in improving animal health and human health.	Qualitative design	World Organization for Animal Health is the global leader and reference organization in animal disease prevention and control, international cooperation on animal health issues (transparency and sharing of veterinary expertise among member countries), and the	Emphasis on capacity building of developing countries especially through the mutual cooperation and collaboration between developing and developed countries. Emphasis on Veterinary Services as a global public good. Governments must continue to

#	Author	Title/Year	Type of Publication	Study Objective(s)	Study Design and/or Methodological Approach	Key Results	Conclusions
						promotion of global safe trade in animal products. Demonstrated through the structure, mandate, activities, and major publications of the organization.	foster closer cooperation with other countries, organizations, and sectors to support Veterinary Services and to share information.
12	Peros et al	Bushmeat, wet markets, and the risks of pandemics: Exploring the nexus through systematic review of scientific disclosures. 2021.	Review	To assess disease surveillance efforts within the bushmeat trade and wet markets globally by compiling zoonotic health risks based on serological examinations, and gauge perceptions of health risks associated with bushmeat and wet markets.	Mixed methods design	Scientific investigations on bushmeat and wet markets retroactively follow disease outbreaks. Oversight of bushmeat, wet markets, and disease are handled separately by different governing bodies. This fails to acknowledge the synergistic risks from the interface of these three issues. Future disease outbreaks can be prevented by tackling the three pillars of pandemics: bushmeat, wet markets, and disease.	An interdisciplinary framework is vital to address the nexus between bushmeat, wet markets, and disease. <u>Research Gap:</u> Bushmeat studies are lacking in Asia and South America - focus is on Africa. <u>Research Need:</u> Standardize perception-based studies grounded in quantitative analyses to inform educational campaigns aimed at raising awareness and conveying zoonotic risks associated with bushmeat. <u>Recommendations:</u> Proactive management and regulation (i.e. monitoring, surveillance, identification) of the bushmeat trade. Wet market policies should focus on increasing accessibility of sanitization and safe meat storage. Research and development of future diseases; stakeholder education of spillover risks.
13	Wingard, et al	Wildlife Trade, Pandemics and the Law: Fighting This Year's Virus with Last Year's Law. 2020.	Review	To review international instruments and responses, and assess the national implementation of a variety of areas of law related to zoonotic disease risk and wildlife trade.	Qualitative design	Legal responses to managing zoonotic disease at the international and national levels are widespread but have not yet evolved sufficiently to address the risks posed by wildlife trade. There is no international framework specifically and comprehensively addressing pathogens of wild animal origin. There is a focus on human health and diseases spread between humans, rather than animals that spread diseases to humans. Proposals to amend international	<u>Research Gaps:</u> Match legal tools identified with field practices and market dynamics to test the value of these tools and to identify others. Identify best practices for the prevention and control of zoonotic disease risks associated with wildlife trade. <u>Future Needs:</u> Define and include wildlife in legislation apart from domestic animals; further connect animal health and welfare, indigenous rights, and different forms of trade (e.g. pet trade) to wildlife trade and zoonotic risk;

#	Author	Title/Year	Type of Publication	Study Objective(s)	Study Design and/or Methodological Approach	Key Results	Conclusions
						instruments will only be able to present partial solutions as they will be limited by their overarching purpose. National approaches vary and are almost always partial - they are limited to domestic animals; only include some wildlife; explicitly exclude wildlife; or only cover some types of activity or setting and not others. The result is a patchwork of approaches with little consistency in how wildlife is factored into disease management systems.	increase the authority of relevant actors to monitor and test and expand this to include wildlife. <u>Recommendations</u> : Maximize the use of legal approaches; explicitly include wildlife and zoonotic risk into legal approaches; increase coordination and harmonizing of laws and standards through cross-referencing; focus on tools to monitor and manage disease.
14	Huang, et al	Will the COVID-19 outbreak be a turning point for China's wildlife protection: New developments and challenges of wildlife conservation in China. 2021.	Policy analysis	To discuss the developments and limitations of the current wildlife legislation in China, and the recommendations for improving Chinese wildlife conservation to better protect biodiversity and reduce risks of spreading zoonotic diseases to humans.	Qualitative design	The current wildlife protection defined by the law does not apply to approximately 1100 species that are not listed as rare or endangered, and is criticized for being outdated and inconsistent. The law also has many ambiguous categories where wildlife can still be utilized for commercial use such as consumption of fur, traditional medicine, and captive breeding, even for some species included in the first-class and second-class lists.	Support for China's wildlife protection law despite severe implementation challenges.
15	Romero-Vidal et al	Confounding Rules Can Hinder Conservation: Disparities in Law Regulation on Domestic and International Parrot Trade within and among Neotropical Countries. 2022.	Article	To review existing national legislation dealing with the trapping, domestic trade and keeping of native parrots as pets, and to compare this information with legal exports reported by CITES to assess differences between the enforcement of international and national trade regulations.	Quantitative design	Only two countries (Guyana and Suriname) currently allow the capture, trade and possession of native parrots, while Peru allowed international legal trade until recently. The other countries have banned parrot trade from years to decades ago. However, the timing of implementation of international and national trade regulations varied greatly between countries, with half of them continuing to export parrots legally years or decades after banning domestic trade.	The implementation of regulations without solving deeper underlying problems such as corruption of the authorities or lack of resources is insufficient, but greater knowledge of this complex legislative network can help in the essential points to combat these illegal practices, such as awareness raising awareness or in promoting research and funding. Neotropical countries are urged to effectively enforce current legislations prohibiting the capture and trade of native parrots—and other wildlife—for the domestic pet demand, otherwise, illegal trade will continue to erode the already

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						The confusion created by this complex legal system may have hindered the adoption of conservation measures, allowing poaching, keeping and trade of protected species within and between neighboring countries.	threatened populations of many parrot species across the Neotropics.
16	Reino et al	Networks of global bird invasion altered by regional trade ban.2017.	Article	To analyze the global trade network of wild-caught birds from 1995 to 2011 as reported by CITES to determine how wildlife trade influences invasion risk.	Quantitative design	Although regional bans can curtail invasion risk globally, to be fully effective and prevent rerouting of trade flows, bans should be global. However, by definition of their regional nature, these bans cannot eliminate trade-driven invasion risk fully.	Network models can be used to identify countries or regions emerging as central to these newly formed trade relations, where new invasions may thus be likely to occur. Investing in better biosecurity, surveillance for likely high-risk invasive species, and improved socio-economic governance in such countries will enable the global community to more effectively prevent and mitigate future biological invasions.
17	Xiao et al	Why do we need a wildlife consumption ban in China? 2021.	Policy Analysis	To analyze why a ban is necessary in China and how its efficacy can be sustained in the future and contribute to global wildlife conservation and human health.	Qualitative design	Current wildlife trade regulations do not function as expected due to outdated protected species lists, insufficient cross-sector collaboration, and weak restrictions and law enforcement on farming and trading of species. The lack of quarantine standards for wildlife and increased wildlife farming in recent years pose great risks for food safety and public health. In addition, wildlife consumption is neither required for subsistence nor an essential part of Chinese diets. The ban is necessary but not sufficient to provoke improvement in wildlife management, such as updating protected species lists, revising laws and changing consumption behaviors.	<u>Recommendation:</u> A long-term mechanism is needed to reduce the demand of wild animal products and improve effective management is needed.

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18	Koh et al	The value of China's ban on wildlife trade and consumption. 2021.	Article	To summarize the development of China's wildlife trade and consumption ban and recommend ways forward.	Qualitative design	The authors argue that while China's decision to ban the trade and consumption of terrestrial wild animals is controversial, it is a viable response to the COVID-19 pandemic.	<u>Future Needs</u> : Need for participation of public and NGOs. Need to provide sufficient support to marginalized groups that may be affected by the ban to ensure behavioural change after the ban. Stop further degradation and destruction of wildlife habitats to further mitigate the risk of zoonotic disease transmission.
19	D'Cruze et al	Clouded in mystery: the global trade in clouded leopards. 2015.	Article	To assess the impact, and describe the trends of the global trade in clouded leopards.	Mixed methods design	CITES records contradictory and incomplete, with data on source country particularly lacking. Shift from animals of unspecified origin for zoological purposes toward commercial trade in captive bred clouded leopards. Increase in illegal poaching of clouded leopard parts for traditional medicine and meat for subsistence.	<u>Research Gaps</u> : Need for research into clouded leopard trade dynamics, e.g. type, volume, trade routes, and attitudes of poachers, traders, and consumers. <u>Recommendation</u> : Extend existing trade bans to include commercial trade in captive bred individuals."
20	Heinrich et al	Strengthening protection of endemic wildlife threatened by the international pet trade: The case of the Australian shingleback lizard. 2022.	Article	To investigate and characterize the international trade in shingleback lizards by summarizing Australian seizure data and international online trade data to curtail the illegal trade in nationally protected species found in international trade.	Mixed methods design	Despite domestic regulation and enforcement of regulation, an international supply chain exists for a protected endemic Australian reptile that involves illegal extraction from the wild, smuggling, and international trade. Contradictory legal frameworks exist in which the import into and trade between other countries is not illegal despite the need for and absence of a federal export permit. These contradictory legal frameworks apply to the majority of nationally protected native fauna.	<u>Recommendation</u> : Listing <i>T. rugosa</i> in Appendix III of the CITES is a meaningful way to provide other countries with the legal means to confiscate illegally exported shinglebacks from Australia.
21	Foster et al	Holding governments accountable for their commitments: CITES Review of Significant Trade for a very high-volume taxon. 2021.	Article	To identify best practices in the Review of Significant Trade CITES process.	Mixed methods design	The Review process did not clearly lead to sustainable trade, the objective of the process. It is common that major exporting Parties are released from taking action under the Review process by declaring suspensions in export that are ultimately unreliable. Recommendations for action under	<u>Recommendations</u> : 1) CITES must insist on outcomes and impacts; 2) CITES must scrutinize and track declarations of export suspension to promote meaningful export regulation; 3) Review recommendations should be tailored to the Party and the species and should have clear metrics for

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						<p>the Review process were constrained by precedents for other taxa and generally lacked metrics to evaluate progress. CITES is not required to consult taxon experts in evaluating progress in addressing Review obligations.</p>	<p>evaluation and success; 4) taxon experts should have a formalized role in the Review process; and 5) a funding mechanism for the Review process must be formalized.</p>

Supplemental Information 3 - Statements authorizing the use of co-authored manuscripts



September 19, 2023

Raphael Aguiar
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RE: Authorization for the use of Co-Authored Manuscript as Chapter 2 in PhD Dissertation

Dear Raphael,

I am writing to formally authorize and grant permission for the use of our co-authored manuscript titled "Preventing zoonotic spillover and infection transmission through regulatory frameworks governing wildlife trade: a scoping review" as Chapter 2 of your PhD dissertation.

This document serves as an official statement authorizing the inclusion of the aforementioned co-authored work in the dissertation titled "Exploring the governance of antimicrobial stewardship and deep pandemic prevention: from siloed approaches to integrative governance models informed by urban political ecology."

If you have any questions or require further information, please do not hesitate to get in contact.

Yours sincerely,

A handwritten signature in black ink that reads "A.M. Viens".

A.M. Viens, BA(Hons), BPhil, PhD, FRSPH, FRSM, HonMFPH
Inaugural Director, School of Global Health
York Research Chair in Population Health Ethics & Law
Faculty of Health
York University



Raphael Aguiar
PhD Candidate
School of Health Policy and Management – York University
Toronto – Canada
Sep 19, 2023

Dr. Chloe Clifford Astbury
School of Global Health
York University, Toronto
Ontario, Canada

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Sincerely,



Dr. Chloe Clifford Astbury
Sep 19, 2023

Raphael Aguiar
PhD Candidate
School of Health Policy and Management – York University
Toronto – Canada
Sep 19, 2023

Dr. Eduardo Gallo-Cajiao
School of Marine and Environmental Affairs
University of Washington
Seattle, WA, USA

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Sep 19, 2023

Raphael Aguiar
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School of Health Policy and Management – York University
Toronto – Canada
Sep 19, 2023

Dr. Mary Wiktorowicz
School of Global Health and Dahdaleh Institute for Global Health
York University, Toronto
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Sep 19, 2023

Raphael Aguiar
PhD Candidate
School of Health Policy and Management – York University
Toronto – Canada
Sep 19, 2023

Dr. Ronald Labonté
Professor Emeritus, School of Epidemiology and Public Health
University of Ottawa, Ottawa
Ontario, Canada

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SEPH
University of Ottawa

Sep 19, 2023

Raphael Aguiar
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School of Health Policy and Management – York University
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Ryan Gray
Dahdaleh Institute for Global Health Research
York University
Toronto, ON, Canada

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Sincerely,



Ryan Gray
Sep 19, 2023

Raphael Aguiar
PhD Candidate
School of Health Policy and Management – York University
Toronto – Canada
Sep 19, 2023

Dr. Arne Ruckert
School of Epidemiology and Public Health
University of Ottawa, Ottawa
Ontario, Canada

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Dr. Arne Ruckert
Sep 19, 2023

Raphael Aguiar
PhD Candidate
School of Health Policy and Management – York University
Toronto – Canada
Sep 19, 2023

Dr. Peter Tsasis
School of Health Policy and Management
York University, Toronto,
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Sep 19, 2023

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Toronto – Canada
Sep 19, 2023

Dr. Mary Wiktorowicz
School of Global Health
York University, Toronto
Ontario, Canada

Subject: Authorization for the use of Co-Authored Manuscript as Chapter 3 in a Ph.D. Dissertation

Dear Raphael Aguiar,

I am writing to formally authorize and grant permission for the use of our co-authored manuscript titled "The Urban Political Ecology of Antimicrobial Resistance: a critical lens on integrative governance " as Chapter 3 of your PhD dissertation.

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Sincerely,



Dr. Mary Wiktorowicz
Sep 19, 2023

Raphael Aguiar
PhD Candidate
School of Health Policy and Management – York University
Toronto – Canada
Sep 19, 2023

Dr. Roger Keil
Faculty of Environmental and Urban Change and Dahdaleh Institute for Global Health Research
York University, Toronto
Ontario, Canada

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Sincerely,



Dr. Roger Keil
Sep 19, 2023

Supplemental Information 3 - Statements authorizing the use of the co-authored manuscript

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Sep 19, 2023

Dr. Mary Wiktorowicz
School of Global Health
York University, Toronto
Ontario, Canada

Subject: Authorization for the use of Co-Authored Manuscript as Chapter 4 in a Ph.D. Dissertation

Dear Raphael Aguiar,

I am writing to formally authorize and grant permission for the use of our co-authored manuscript titled "One Health governance of antimicrobial resistance seen through an Urban Political Ecology lens: A Critical Interpretive Synthesis " as Chapter 4 of your PhD dissertation.

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Sep 19, 2023

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Sep 19, 2023

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