



Risk communication about antimicrobial resistance: a content analysis of metaphor use in global public discourse

Eva M. Krockow, Meghann Jones, Carolyn Tarrant, Marc Mendelson & Stephen J. Flusberg

To cite this article: Eva M. Krockow, Meghann Jones, Carolyn Tarrant, Marc Mendelson & Stephen J. Flusberg (2024) Risk communication about antimicrobial resistance: a content analysis of metaphor use in global public discourse, *Journal of Risk Research*, 27:12, 1605-1622, DOI: [10.1080/13669877.2025.2485044](https://doi.org/10.1080/13669877.2025.2485044)

To link to this article: <https://doi.org/10.1080/13669877.2025.2485044>



© 2025 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group



[View supplementary material](#)



Published online: 06 Apr 2025.



[Submit your article to this journal](#)



Article views: 251



[View related articles](#)



[View Crossmark data](#)

Risk communication about antimicrobial resistance: a content analysis of metaphor use in global public discourse

Eva M. Krockow^a, Meghann Jones^a, Carolyn Tarrant^b, Marc Mendelson^c and Stephen J. Flusberg^d

^aSchool of Psychology and Vision Sciences, University of Leicester, Leicester, UK; ^bDepartment of Population Health Sciences, University of Leicester, Leicester, UK; ^cDivision of Infectious Diseases & HIV Medicine, Department of Medicine, Groote Schuur Hospital, University of Cape Town, Cape Town, South Africa; ^dDepartment of Cognitive Science, Vassar College, Poughkeepsie, NY, USA

ABSTRACT

Antimicrobial resistance (AMR) poses an existential threat to humanity, yet public awareness remains low. An underexplored tool for AMR risk communication is metaphor. By inviting a comparison between abstract and familiar concepts, metaphors can make complex health information more accessible. However, metaphor use in the context of AMR has been haphazard and remains poorly understood. We address this issue by providing an integrative content analysis of metaphor use in global, English-language, public AMR discourse. Four types of public sources were searched: (1) websites of 71 non-profit organisations, (2) national AMR action plans from 84 countries, (3) 819 international newspaper articles and (4) 2,616 social media posts. Across all sources, 2,149 metaphors excerpts were extracted. Qualitative content analysis identified 41 distinct metaphor themes, but 75% of metaphors fell into one of four themes: ‘War against resistance, infections and microbes’, ‘Heroes and villains of resistance’, ‘Post-antibiotic apocalypse and looming crisis of AMR’, and ‘Silent, creeping threat of AMR’. All key themes are inapt or theoretically problematic by painting a misleading picture of a finite struggle between good and evil, which does not match the ecological reality of a continuously evolving challenge. Furthermore, most existing metaphors are highly conventional and emotive. They aim to raise general awareness about AMR without conferring specific knowledge. Our findings call for an urgent re-framing. Media, policy makers and health officials should choose theoretically informed, apt and novel explanatory metaphors that are specific to the context of AMR and challenge public misunderstandings with the potential to prompt behaviour change.



Abbreviations: AMR: antimicrobial resistance; MRSA: methicillin-resistant *Staphylococcus aureus*; WHO: World Health Organisation; FAO: Food and Agriculture Organisation; GARDP: Global Antibiotic Research and Development Partnership; CARB-X: Combatting Antibiotic-Resistance Bacteria; PSK: Pharmaceutical Society of Kenya; WAAW: World Antibiotics Awareness Week; ICARS: International Centre for Antimicrobial Resistance Solutions; OIE: World Organisation For Animal Health; PACE: Pathways to Antimicrobial Clinical Efficacy; ReAct: Action on Antibiotic Resistance


ARTICLE HISTORY

Received 1 October 2024
Accepted 13 March 2025

KEYWORDS

antimicrobial resistance;
antibiotic resistance;
public health; risk
communication;
metaphor; analogy

CONTACT Eva M. Krockow  emk12@le.ac.uk  School of Psychology and Vision Sciences, University of Leicester, University Road, Leicester LE1 7RH, UK

 Supplemental data for this article can be accessed online at <https://doi.org/10.1080/13669877.2025.2485044>.

© 2025 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

Introduction

Previous risk communication about antimicrobial resistance (AMR) has been unsuccessful in raising sufficient public awareness about the existential threat imposed by drug-resistant infections (Krockow et al. 2023; McCall et al. 2023; Wellcome Trust 2019). AMR refers to the process whereby microbes such as bacteria develop protective mechanisms against drugs such as antibiotics, meaning that those drugs become ineffective for treating bacterial infections. The global death toll associated with AMR in 2019 was estimated at 4.95 million (Murray et al. 2022), and is projected to rise to an annual number of over 8 million deaths by 2050 (Naghavi et al. 2024).

Despite these alarming figures, health risk literacy about AMR remains low (Govindan 2018; Singh-Phulgenda et al. 2023; WHO 2015). Research has highlighted persistent misconceptions including a belief in antibiotic effectiveness for viral illnesses and a mistaken assumption that it is the human body (as opposed to the bacteria), which develops resistance to antibiotics (Brookes-Howell et al. 2012; Chukwu et al. 2020; Muflih et al. 2021; Singh-Phulgenda et al. 2023). Low levels of AMR health risk literacy may be attributed, at least in part, to insufficient or ineffective health risk communication about the problem (Krockow et al. 2023; Wellcome Trust 2019). Media coverage about AMR has been sparse compared to related health threats such as sepsis (Fitzpatrick et al. 2019; Rush et al. 2019). Additionally, previous research has questioned the effectiveness of language used to communicate about the threat of AMR (Wellcome Trust 2019). Health campaigns and public-facing materials were criticised for their abstract wording and inconsistent use of language and terminology (Krockow 2020; Krockow et al. 2023; Mendelson et al. 2017; Wellcome Trust 2019), which is difficult to remember, insufficient for generating appropriate risk perceptions (Krockow et al. 2023) and fails to translate into other languages and cultures (Mokoena, Schellack, and Brink 2021).

An underexplored tool for communicating the risks of AMR is metaphor. Metaphor is a figure of speech that involves using words which literally apply to one thing (the 'source') to figuratively describe another (the 'target'), as in the expression 'bacteria are *foreign invaders*'. This invites a comparison, highlighting correspondences between the two domains: just as hostile enemy soldiers can invade a country and wreak havoc, so too can bacteria enter and damage the human body.

Metaphor use is pervasive in public discourse and in everyday speech (Flusberg, Matlock, and Thibodeau 2018; Flusberg and Thibodeau 2023; Lakoff and Johnson 1980; Nerlich 2009; Thibodeau and Boroditsky 2011; Thibodeau, Matlock, and Flusberg 2019). This is because metaphor enables people to communicate and reason about abstract, complex, and novel topics by leveraging what they know about more familiar domains, such as war (Thibodeau, Matlock, and Flusberg 2019). For example, a 2021 UK health campaign likened COVID-19 to *smoke* and urged the population to 'stop COVID-19 *hanging around*' (Department of Health and Social Care 2021). This conveyed a simple, accessible message about the build-up of COVID-19 particles in unventilated spaces, avoiding the need for detailed scientific explanations. Many studies have shown that metaphor framing can lead people to reason in metaphor-consistent ways about the problem (Thibodeau and Boroditsky 2011). In the context of health messaging, for example, metaphors can facilitate communication about the toxicity of heavy metals (Bostrom 2008), COVID-19 risks (Bruine de Bruin, Carman, and Parker 2021), pain management (Gallagher, McAuley, and Lorimer 2013), influenza vaccines and breast mammography (Galesic and Garcia-Retamero 2013), and skin cancer risks (Landau, Arndt, and Cameron 2018).

Metaphors vary in multiple ways that moderate how effective they are in shaping public reactions to complex issues (Flusberg and Thibodeau 2023; Thibodeau, Matlock, and Flusberg 2019). For example, metaphors are more *apt* when it is easy to map the structure of the source domain onto the target and when they communicate something relevant about the target domain. The *smoke* metaphor for COVID-19 is apt because respiratory viruses do linger in the

air in unventilated spaces, but this may go unnoticed because viruses are invisible to the naked eye (unlike smoke). Apt metaphors can help people think about abstract topics in new ways, which can promote attitude and behaviour change. However, inapt metaphors often find their way into public discourse. Some experts have criticised the use of war metaphors to frame the global response to COVID-19, for instance, arguing that the metaphor does not accurately capture how the disease spreads (Flusberg, Matlock, and Thibodeau 2018; Hauser and Schwarz 2015; Semino 2021).

That said, metaphors are sometimes impactful because they are emotionally resonant, not because they are particularly apt. Metaphors that evoke strong negative emotions, like war metaphors, are especially attention-grabbing, making issues like a pandemic or climate change feel more urgent (Flusberg, Matlock, and Thibodeau 2017, 2018). This may be useful for raising awareness and concern. However, emotionally charged metaphors can backfire if they convey the sense that a situation is hopeless, which undermines the motivation to engage (Flusberg, Matlock, and Thibodeau 2018; Hart 2021; Nerlich 2009).

Another relevant dimension of metaphor is conventionality. Some metaphors are highly conventional, appearing frequently in many different contexts. In addition to metaphorical *wars* on COVID-19, climate change, crime, cancer, and poverty, for example, statements describing a *fight*, *combat*, or *battle* with infectious diseases have dominated medical discourse for decades (Flusberg, Matlock, and Thibodeau 2018; Maccaro 2021; Nerlich 2009). Indeed, the notion of violence may be intrinsically linked to the concept of antibiotics, whose etymological ancestor – *antibiosis* – literally translates as ‘against life’ (Servitje 2021). Conventional metaphors typically draw on source domains that reflect universal elements of human experience, such as the *body*, *space*, *animals*, *games*, *war*, and *disease* (Lakoff and Johnson 1980). While they often go unnoticed and are quickly forgotten, they can still serve as effective framing devices (Thibodeau and Boroditsky 2011). However, people may reach for conventional metaphors because they confuse accessibility with aptness, as the discussion of war metaphors above suggests (Thibodeau and Durgin 2011).

In many cases, novel metaphors are particularly effective for communicating about complex issues (Flusberg and Thibodeau 2023). Novel metaphors are processed differently than conventional metaphors, requiring additional cognitive resources to align source and target domains (Bowdle and Gentner 2005). This can make them useful tools for explanation, especially when they are elaborated to an audience and highly *systemic*, capturing many meaningful shared relations across the two domains (Flusberg and Thibodeau 2023). For example, explaining how the atmosphere is similar to a *bathtub* was shown to improve how people reason about carbon accumulation and global warming (Guy et al. 2013). Novel metaphors that are regularly used to frame a particular issue in the public interest are sometimes called *discourse metaphors* (Nerlich 2009; Zinken, Hellsten, and Nerlich 2008). In the context of AMR, novel discourse metaphors permeate attention-grabbing news headlines and politically charged speeches of international leaders and health authorities. For example, people issue dire warnings about a *post-antibiotic apocalypse* (Nerlich 2009; Servitje 2019), a *silent tsunami* (Harvey 2019), and a *lobster put into cold water, heating up slowly, not making any noise as it dies* (Davies 2021). However, while these metaphors evoke an emotion-laden conception of the problem, these source domains do not impart a rich structural model of the nature of AMR or how it should be dealt with.

Systematic research on metaphor use in the context of AMR is sparse. Therefore, it is unclear how often people are exposed to various metaphor frames, and the impact this may have on public understanding of the issue. Between 2006 and 2009, several mixed-methods investigations explored UK media frames pertaining to methicillin-resistant *Staphylococcus aureus* (MRSA) (Brown and Crawford 2009; Crawford et al. 2008; Koteyko et al. 2007; Nerlich 2009; Washer and Joffe 2006). Koteyko et al. (2007) evidenced the use of figurative speech by highlighting a ‘lack of *silver bullets*’ frame, which emphasised the absence of simple solutions to the problem of hospital-acquired infections. Other analyses have pointed to the frequent personification of

bacteria as *dangerous, intelligent actors* (Crawford et al. 2008) and the use of the term *superbug*, which evokes a conception of bacterial indestructibility (Washer and Joffe 2006).

A handful of studies have focused explicitly on metaphor use in media and academic coverage of AMR. A qualitative analysis of English-language newspaper articles highlighted the use of both conventional and novel discourse metaphors, mainly drawing on the source domains of *war, competition, and the apocalypse* (Nerlich 2009). A similar assessment of AMR news reporting in Australia identified six common metaphorical themes: *superbugs, military, crime, epidemic, doomsday, and blaming others* (Bouchoucha, Whatman, and Johnstone 2019). These findings were echoed in a study of German newspaper articles, which highlighted frequent metaphor use and a range of source domains, including *war, economy, space, machines, water, police/crime* and *sports/games* (Peters et al. 2019). Finally, a recent study presented a discourse analysis of conventional metaphor use in a small sample of academic publications relating to the transmission of AMR (Kamenshchikova et al. 2023). The authors highlighted a tendency to describe bacteria as *foreign strangers*.

Taken together, previous research insights pertaining to AMR-related metaphor use are at best incomplete. Much of the existing research is now outdated, or else findings are limited by a narrow research focus (e.g. research questions specifically pertaining to MRSA), country-specific media analyses, or search strategies limited to academic discourse. No investigation to date has considered broader publication sources or attempted a global analysis of metaphor use by a range of international stakeholders.

Research aims and objectives

We addressed the following central research question:

- What is the incidence and nature of current metaphor use in global, English-language communications and public discourse about AMR?

We aimed to answer this question through three objectives:

1. Identify metaphors used to communicate about AMR, microbes and/or antimicrobial medicines across a broad range of international English-language sources within the public domain.
2. Provide a qualitative content analysis of the frequency and distribution of different metaphors in AMR discourse, including a thematic mapping of source domains, an analysis of different metaphor types, dimensions, and a comparison of metaphors across different geographic contexts and publication sources.
3. Provide a theory-based evaluation of metaphor use in the context of AMR, highlighting any existing empirical evidence on the effectiveness of common metaphors used in the context of AMR risk communication.

Method

Identification of relevant sources

Our search spanned four different types of sources: (1) webpages of non-profit organisations and government bodies, (2) electronic national action plans on AMR, (3) online records of newspaper articles, and (4) social media posts on Twitter/X. Our search was conducted in July 2024. Sources were eligible for inclusion in our analysis if they were English-language publications created to raise awareness, increase knowledge, inform the public discourse, disseminate

news, or share comments about AMR, microbes and/or or antimicrobial medicines. For webpages and national AMR action plans, we considered materials between 01 January 2014 and 31 July 2024 with the lower date boundary coinciding with the publication year of the first WHO Global report on AMR. For newspaper articles, we included articles published between 1 and 30 November 2023, which covered World AMR Awareness Week, and articles published 6 months later, between 1 and 31 May 2024. By choosing two months at opposite ends of the calendar,

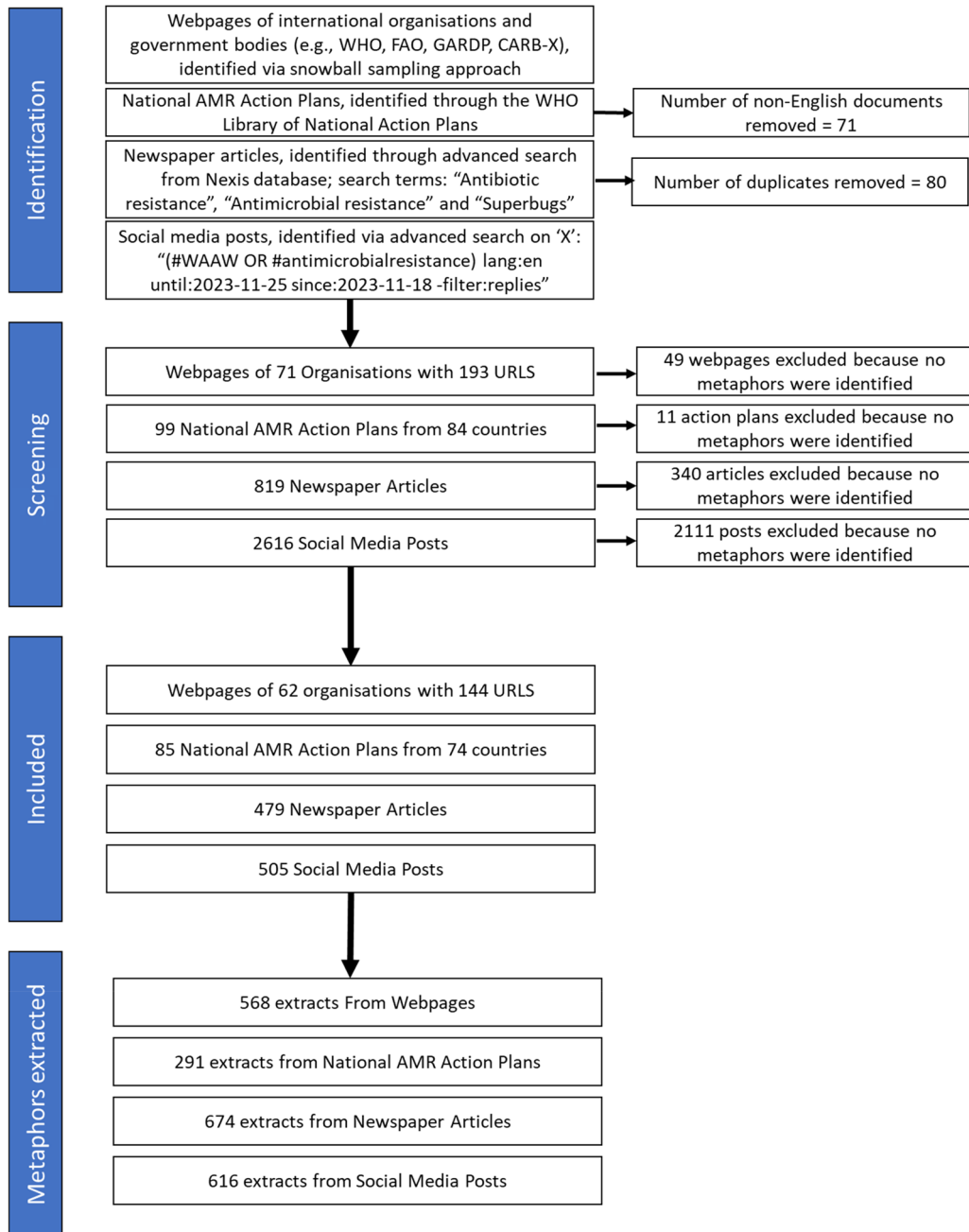


Figure 1. Search strategy for each data source and number of metaphors extracted.

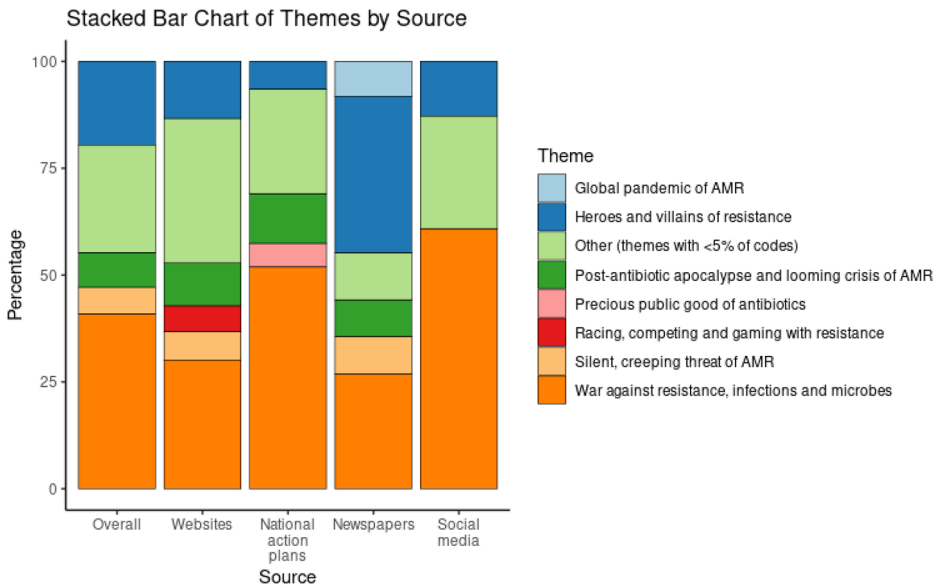


Figure 2. Overview of metaphor themes by source.

we hoped to mitigate any seasonal news effects. For social media posts on X (formerly Twitter), we included a date range from 18 to 24 November 2023, coinciding with World AMR Awareness Week. We excluded materials published in audio and video format or any purely visual materials. Our search strategy is shown in Figure 1. A more detailed, narrative overview is provided in Material 1 of Supplementary Appendix A.

Data extraction and analysis

We extracted any use of metaphors to communicate about AMR, microbes, and/or or antimicrobial medicines. We used a broad working definition of metaphors as any instance in which language is used to describe one concept in terms of another (Lakoff and Johnson 1980). Metaphor identification was guided by the ‘metaphor identification procedure’ (Group 2007). This included a general reading of the documents to get an overall sense of their meaning. Then, text was broken down into smaller lexical units, considering whether specific units had another basic meaning in a different context. We then conducted a qualitative content analysis to identify metaphorical themes or frames across our diverse sources and quantified the proportion of metaphor tokens belonging to each category (Flick 2013; Hsieh and Shannon 2005). Instead of focusing on traditional metaphorical source domains (e.g. ‘space’, ‘war’, ‘crime’, and ‘agents’), our analysis aimed to distil broader themes or topics which underlie metaphorically-framed AMR communications. Themes may contain metaphors that draw upon different source domains which all function to reinforce the same general frame (see Table 1). Our approach involved an initial process of open semantic coding, which was subsequently refined during several iterative rounds of abstraction to arrive at overarching thematic categories. For each data source, one lead researcher (EK) conducted the coding and derived the themes of all original text extracts. A second researcher (MJ) subsequently coded a randomly chosen sub-section of 10% of text extracts. Coding and thematic categorisations were compared between researchers and any differences discussed until a joint approach was agreed upon. The analytic process was supported through discussions with the research team, which also involved considerations of previous metaphor categorisation proposed in the literature. Data can be accessed in Supplementary Appendix B.

Table 1. Seven most frequent metaphor themes, ordered by total number of occurrences across all sources (most frequent themes first).

Metaphor theme	Description	Example extracts (metaphor highlighted in <i>italics</i>)	Source
*War against resistance, infections and microbes	Metaphors describe a military or violent conflict with varying enemies, including AMR, infections, specific diseases such as gonorrhoea, microbes and specific multi-drug resistant organisms such as MRSA. The most common extracts are highly conventional and refer to <i>fighting, combating or battling</i> resistance. Additional metaphors include <i>self-defence, fighting back and shielding</i> from hostile forces. Antibiotics are often portrayed as <i>weapons</i> , which includes comparisons with <i>bullets</i> or <i>artillery</i> or references to antibiotic <i>arsenal</i> . One sub-theme includes <i>revolution</i> , in which antibiotics are likened to medical revolutionaries. Metaphors frequently include personification. For example, microbes or superbugs are described as independent agents (e.g. as <i>killers</i> and <i>foes</i>).	In search of an <i>Armor-Busting</i> antibiotic <i>Warfare</i> waged against antimicrobial resistance Superbugs evolve ever more potent <i>defenses</i> against our dwindling <i>antibiotic arsenal</i> Australia is winning the <i>battle but losing the war</i> against #AMR drug-resistant infections! Despite a 19% drop in antibiotic use, experts warn the <i>fight</i> is far from over.	One Health Trust Podcast webpage Japan National action plan on antimicrobial resistance (AMR), 2016–2020 The Northlines India newspaper article, 15 May 2024 X post by CareerSpot (@CareerSpotMedia), 21 November 2023
*Heroes and villains of resistance	AMR is described as an interplay between dual forces or superpowers of good and evil. This theme chiefly contains references to powerful <i>superbugs</i> , sometimes adorned with adjectives such as <i>invincible</i> or <i>immortal</i> . Additional use of personification frequently describes these superbugs as <i>evil, stubborn, villains, culprits</i> or trespassers, who are <i>disrespectful of borders</i> and boundaries. This is contrasted with descriptions of antibiotics as benevolent <i>superheroes</i> , which offer much-needed protection.	<i>Superbugs dragged</i> the medical and scientific communities <i>to their knees</i> Antibiotic-resistant bacteria <i>do not respect international borders</i> Leading to the rise of <i>near-invincible superbugs</i> Introducing antimicrobial resistance: the villain to our <i>modern medicine superhero</i> .	AMR Declaration Trust online publication 'No Option' Dutch national action plan on AMR, 2015–2019 The Guardian newspaper article, 17 May 2024 X post by CSIRO (@CSIRO), 20 November 2023
*Post-antibiotic apocalypse and looming crisis of AMR	AMR is described using apocalyptic, fictitious scenarios and descriptions of intensely difficult looming challenges, which highlight an existential threat. Common subthemes include synonyms of <i>crisis</i> including <i>alarm, catastrophe, emergency, devastation, disaster, desperation</i> and <i>tragedy</i> , which are often combined with adjectives that express impending doom (e.g. <i>looming</i> or <i>dire</i>). AMR is sometimes compared to other previous or ongoing crises, including the <i>2008 financial crisis</i> . Metaphors such as <i>(post-antibiotic) apocalypse</i> and <i>armageddon</i> warn about an ending of the world as we know it. References to <i>nightmares, horror stories, monsters</i> and <i>pandora's box</i> have fictional elements. Metaphorical comparisons with <i>timebombs</i> are used to highlight the extreme urgency of the threat. This theme does not include geophysical threats, which are covered under a separate, smaller theme.	No time to wait: evaluating the fight against ' <i>Drugmageddon</i> ' Having recognised the <i>looming crisis</i> , the Government has prioritised the prevention and containment of AMR Antimicrobial resistance (AMR) is a <i>global health crisis</i> that threatens to undo the miracle of antibiotics Medicine will be taken back to the ' <i>dark ages</i> ' if antibiotics are rendered ineffective	ITAD webpage Kenya National Action Plan on Prevention and Containment of Antimicrobial Resistance 2017–2022 X post by The Pharmaceutical Society of Kenya (PSK) (@PSofKenya), 22 November 2023 Mail Online newspaper article, 13 May 2024

(Continued)

Table 1. Continued.

Metaphor theme	Description	Example extracts (metaphor highlighted in <i>italics</i>)	Source
*Silent, creeping threat of AMR	AMR is described as a hidden, imperceptible and slowly advancing threat. Metaphorical contents include references pertaining to visual and auditory perception such as <i>invisible, hidden, silent, unseen, masked and veiled</i> . The global community is being described as <i>asleep</i> or <i>sleepwalking</i> , thereby indicating their ignorance of the threat. AMR is contrasted with other international challenges based on the perpetual nature of the threat, with references made to <i>slow motion</i> . Notably, a lot of the figurative speech takes the form of adjectives and occurs in combination with other metaphorical descriptions of the threat of AMR. Examples include <i>invisible crisis, silent pandemic</i> and <i>slow-motion tsunami</i> .	COVID-19 is like dropping the lobster into boiling water: you know instantly that you have a problem. AMR, on the other hand, is like <i>gradually</i> heating the water: you don't know until too late that you have a problem. Right now, we are the lobster in the pot that is <i>slowly heating!</i> <i>Silent yet dire crisis</i> Issuing <i>wake-up calls</i> to a world that keeps <i>wanting five more minutes of sleep</i> As #WAAW goes on, #AfroACDx participants contributed to a particularly dynamic and active session on #RAM, the <i>silent and invisible</i> epidemic responsible for the deaths of 5 million people a year	AMR.Solutions webpage National strategic plan for combating antimicrobial resistance in Sri Lanka 2017–2022 Scotsman newspaper article, 15 November 2023 X post by Fondation Mérieux (@MerieuxFdn), 21 November 2023
Global pandemic of AMR	The challenge of AMR is likened to a global disease outbreak. Sub-themes include metaphorical comparisons with <i>epidemics, pandemics</i> and <i>plagues</i> . Direct comparisons with the recent COVID-19 pandemic are frequent.	The sobering numbers are undoubtedly cause for alarm, particularly as we continue to live under the <i>grip of the 'other' pandemic</i> This silent <i>AMR pandemic</i> has long taken its roots, causing increased morbidity, mortality, and catastrophic financial consequences Sleepwalking into the <i>pandemic of pandemics</i> Prevent #AntimicrobialResistance (#AMR) from becoming the <i>next global pandemic</i> .	ICARS International Centre for Antimicrobial Resistance Solutions webpage Malaysian action plan on antimicrobial resistance (MyAP-AMR) The Telegraph newspaper article, 16 May 2024 X post by The Partnership to Fight Infectious Disease (PFID) (@ThePFID), 22 November 2023
Racing, competing and gaming with resistance	AMR is compared to competitive (sporting) events or games. The most common sub-theme is the <i>race against resistance</i> , which includes references to <i>outpacing</i> or <i>keeping pace</i> with AMR or stopping resistance in its <i>tracks</i> . Additional metaphorical comparisons from the area of athletics include the mentions of <i>hurdles</i> and <i>relay</i> . Frequent references to <i>winning against</i> or <i>beating</i> drug-resistant bacteria highlight the competitive notion of this theme. Some metaphors included in this theme refer to <i>gaming</i> and <i>gambling</i> contexts.	Drug resistance doesn't have to mean ' <i>Game Over</i> '. The <i>speed</i> with which resistance has been developed <i>has not been matched</i> with development of new antibiotics Superbugs on a <i>winning streak</i> AMR Awareness Week may end today for another year, but the work continues. Read about PACE in this new article: ' <i>Keeping PACE</i> with antibiotic resistance.'	GARDP website Egypt National action plan for antimicrobial resistance, 2018–2022 Sunday Times Sri Lanka newspaper article, 26 November 2023 X post by PACE (@PACE_AMR), 24 November 2023

(Continued)

Table 1. Continued.

Metaphor theme	Description	Example extracts (metaphor highlighted in <i>italics</i>)	Source
Precious public good of antibiotics	Antibiotics are described as a rare and treasured resource that belongs to the public or wider community as opposed to individual doctors or patients. Common sub-themes include metaphorical adjectives such as <i>precious</i> and <i>scarce</i> . References to antibiotics' limited <i>shelf life</i> and drugs <i>running out</i> highlight that future availability is questionable. Descriptions of antibiotics as <i>public goods</i> and <i>public resources</i> highlight global stakes and responsibilities. While some of these descriptions may appear literal, it is noteworthy that antibiotics per se are often easily available and inexpensive, thereby creating a deviation from purely literal language.	To ensure that these <i>precious</i> drugs are used responsibly and remain effective in the future	OIE webpage
		Responsibility to protect <i>valuable source</i> of antibiotics for the next generation	National action plan for combating drug resistance, 2013–2020
		The medicine cabinet is <i>bare</i>	Hindustan Times newspaper article, 2 May 2024
		Antibiotics are a <i>precious resource</i> .	Post by مؤسسة الرعاية الصحية الأولى (@PHCCqatar), 23 November 2023

Notes: Themes were included if they accounted for at least >5% of extracts for any one source. The four most common themes are marked with asterisks. Example quotations were provided from all four sources. An exception was made for social media data, where the provision of examples would have identified individual social media users.

Results

Our web search identified 41 distinct themes across the four data sources. We identified seven frequently used themes, which reached a threshold of 5% of metaphor extracts per source. A quantitative overview of the relative frequency of themes for each source is provided in Figure 2. A more detailed, narrative comparison of sources is provided in Material 5 of Supplementary Appendix A.

Additional quantitative information about all theme counts and percentages is provided in Table 1 of the Supplementary Appendix A. The four most common themes across all sources included 'War against resistance, infections and microbes', 'Heroes and villains of resistance', 'Post-antibiotic apocalypse and looming crisis of AMR' and 'Silent, creeping threat of AMR'. Overall, these four themes accounted for 75% of all metaphors extracted. All other themes appeared comparatively infrequently, with many themes only accounting for one or two individual metaphor extracts. Descriptions of the seven most common themes including example quotations and their respective sources are provided in Table 1. A full list with all themes and example quotations can be found in Table 2 of Supplementary Appendix A. Most materials contained combinations of many different metaphor themes, often within a single sentence or heading. Some of these included frequently repeated metaphorical catchphrases such as *silent tsunami* and *invisible pandemic*. Others were context-specific metaphor combinations, jointly used to increase impact. Examples include: 'These *wonder drugs* defeat *killer microbes* and have *revolutionized* medicine', (One Health Trust webpage), and 'It is a global health *timebomb*: an *invisible pandemic* with the potential to leave mankind exposed to a new generation of *superbugs*' (PACE webpage).

Comparison of metaphor dimensions

A schematic overview of metaphor dimensions across the seven main themes is presented in Figure 3.

Metaphor use across all four sources was highly conventional. The frequent calls to *fight*, *combat*, or *battle* AMR are consistent with how subtle *war* metaphors are deployed in many sociopolitical contexts and did not appear to be based on carefully considered word choices (Flusberg, Matlock, and Thibodeau 2018). Furthermore, very few of the metaphors were novel

	Conventional	Emotional	Systemic
War against resistance, infections and microbes	▲	▲	▲
Heroes and villains of resistance	▲	▲	▲
Post-antibiotic apocalypse and looming crisis of AMR	▲	▲	▲
Silent, creeping threat of AMR	▲	▲	▲
Global pandemic of AMR	▲	▲	▲
Racing, competing and gaming with resistance	▲	▲	▲
Precious public good of antibiotics	▲	▲	▲

Figure 3. Schematic overview of metaphor dimensions across the most common themes. The assessment is based on qualitative insights developed during our content analysis. Larger triangles indicate higher qualitative ratings on the respective dimension.

or unique to the context of AMR. Metaphorical comparisons with *war*, *pandemics*, and *natural disasters* are commonplace in risk communication about other global challenges such as climate change or terrorism (Flusberg, Matlock, and Thibodeau 2018; Rodehau-Noack 2021). While some metaphorical catchphrases such as *post-antibiotic apocalypse* and *superbugs* were specific to AMR, their novelty remains questionable. *Superbugs* in particular was used almost synonymously with AMR, thereby reducing its ability to evoke a novel conceptualisation of the issue.

Almost all metaphorical contents ranked highly on the emotional dimension. Key examples of this included metaphors falling within the themes of war and racing, which attempt to stimulate enthusiasm or inspiration by encouraging people to join *forces*, step up to the challenge of a *race*, and join the global *fight* against AMR. Metaphors from post-apocalyptic and pandemic themes generate more severe emotions of panic, doom, and despair, with the apparent purpose of raising awareness about the frequently overlooked risk of AMR. Some metaphors seemingly aimed to evoke positive, or even grateful or loving feelings towards antibiotics, resistance, and microbes. This includes a few metaphors describing a necessary *balance* or *dance* between humans and microbes by publications from the ReAct global network and the Samoan slogan of 'Fa'aāoga with Love' (i.e. use [antibiotics] with *love*), cited in the Samoan National AMR action plan.

Very few metaphors communicated knowledge about systemic properties of AMR, antibiotics, or microbes. The majority aimed to raise general awareness about AMR, with only a small proportion trying to explain functional details of drug resistance or biological cell mechanisms. One such rare example was the comparison of microbial structures to *pumps* to explain biological processes involved in the development of antibiotic resistance. Another example was the use of a *fire extinguisher* metaphor by the AMR.Solutions webpage to explain the role of antibiotics as healthcare infrastructure reserved for medical emergencies. Finally, a social media comparison of antibiotics with individual hygiene or medical items such as *toothbrushes* and *nasal sprays* evoked an understanding of the personal nature of antibiotic prescriptions, highlighting problematic behaviours of sharing medicines with family and friends.

Discussion

We conducted the first global web search and content analysis of metaphors in English language communications about AMR in order to thematically analyse, and appraise metaphor use from four global online sources.

Metaphor incidence and themes

Our results demonstrate the ubiquitous nature of metaphor use in public AMR discourse. We identified 41 distinct metaphor themes across all sources, but the majority of metaphors fell into one of four themes: 'War against resistance, infections and microbes', 'Heroes and villains of resistance', 'Post-antibiotic apocalypse and looming crisis of AMR' and 'Silent, creeping threat of AMR'. The war theme was the most dominant overall. Most codes included subtle references to *fighting*, *combating*, and *battling* AMR, infections or microbes such as superbugs. Antibiotics were frequently portrayed as *weapons* in this violent struggle. The heroes and villains theme chiefly included descriptions of omnipotent, *evil superbugs*, which were contrasted with the *heroic superpower* of antibiotics. The apocalyptic theme included fictitious doomsday scenarios, foretelling a return to the medical *dark ages* or a *looming crisis*. The silent threat theme evoked notions of imperceptibility through the use of adjectives such as *silent*, *hidden*, *invisible* and *slow-motion*.

The core themes identified in our study echo previous research, which identified doomsday, epidemic, crime and sports metaphors in AMR discourse (Bouchoucha, Whatman, and Johnstone 2019; Nerlich 2009; Peters et al. 2019), and described media frames of antibiotic-resistant bacteria (specifically MRSA) as omnipotent *superbugs* (Brown and Crawford 2009; Crawford et al. 2008; Koteyko et al. 2007; Nerlich 2009; Washer and Joffe 2006). However, many of our other themes – particularly 'Silent, creeping threat' and 'Precious public good' – extend the body of previously identified AMR metaphors. The greater metaphor diversity evidenced in our study is likely due to the global and varied scope of our metaphor search, which extends previous single-country, media-focused investigations (Bouchoucha, Whatman, and Johnstone 2019; Nerlich 2009; Peters et al. 2019).

Our thematic analysis also provides more nuanced insights into well-established metaphor domains, including *warfare*. The present results suggest surprising heterogeneity pertaining to the entities portrayed as *enemies*. Metaphorical enemies included infections, microbes, bacteria, superbugs, AMR, and people or organisations who misuse antibiotics. A few selected materials even described microbes *fighting* against antibiotics in an act of *self-defence*, thereby painting antibiotics as aggressors. Similarly, our theme of heroes and villains sheds new light on the use of common metaphorical tropes in this domain. The term *superbug* had been highlighted in a previous Australian newspaper analysis (Bouchoucha, Whatman, and Johnstone 2019), yet our thematic analysis demonstrates how this slogan is situated within a broader conception of the issue as *duelling forces* of resistance – *superbug villains* versus *antibiotic heroes*.

The majority of metaphors identified in our study were highly conventionalised and included subtle and habitual references to the *fight* against *superbugs* or the necessary protection of the *precious public good* of antibiotics. We observed very few unique or novel metaphorical comparisons. War metaphors, for example, are not specific to AMR, even within standard medical discourse. Instead, they are part of a general trend of 'biomilitarism' (Larson, Nerlich, and Wallis 2005; Montgomery 1991) and feature heavily in the broader framing of other socio-political issues such as crime and climate change (Flusberg, Matlock, and Thibodeau 2018). Most metaphors identified in our study were aimed at increasing risk perceptions through emotional imagery, while providing few systemic mappings to increase knowledge about biological mechanisms of AMR or the spread of infection. Indeed, none of the metaphors identified in our search addressed any of the pervasive public misconceptions about AMR that were identified in the Introduction.

Our findings around conventionality align with and extend previous research. Nerlich (2009) highlighted the tacit, commonplace use of war metaphors in newspaper articles about AMR in the 1990s and early 2000s, alongside a few examples of novel metaphors, most notably *post-antibiotic apocalypse*, coined by Richard James in 2005 (James 2005, as cited in Nerlich, 2009). Yet, it appears that the repeated use of such novel metaphors has led to conventionalisation over time. Bouchoucha, Whatman, and Johnstone (2019) commented on this phenomenon

in their analysis of the superbug metaphor. The term *superbug*, which emerged in the 1990s and was most commonly used to describe MRSA, now appears to be used inadvertently, casually, and apparently synonymously with the broader concept of AMR (Cannon 1995; Musolff and Zinken 2009; Nerlich and Koteyko 2009).

Appraisal of metaphor effectiveness

Previous literature suggests that metaphorical effectiveness is highest for metaphors with familiar, non-divisive, and universally meaningful source domains (Sopory and Dillard 2002; Thibodeau, Hendricks, and Boroditsky 2017; Van Stee 2018). Novel metaphors are typically viewed as more effective than conventional metaphors in challenging existing beliefs and creating fresh insights (Brugman, Burgers, and Steen 2017; Sopory and Dillard 2002; Van Stee 2018). Furthermore, single, extended metaphors appear more persuasive than multiple mixed metaphors (Sopory and Dillard 2002) due to their ability to create consistent organisation of thought and a clearer mapping between source and target domains. In particular, novel, elaborated, and systemic metaphors are often best suited for explaining complex topics like vaccination and climate change (Flusberg, Mackey, and Semino 2024; Flusberg and Thibodeau 2023; Guy et al. 2013).

Most metaphor themes identified in our research (e.g. pertaining to war, superpowers, doomsday scenarios, and imperceptibility) fulfil criteria around source familiarity. Yet, the high degree of conventionality and common practice of metaphor mixing is problematic when aiming to increase the impact of metaphorical language. The frequent use of non-specific war and doomsday metaphors may help to evoke emotional responses and raise awareness and risk perceptions. Similarly, a combination of multiple metaphors may grab attention. However, these types of metaphors are unlikely to challenge existing misperceptions or foster clear and coherent mental models about AMR (Sopory and Dillard 2002). Additional, more nuanced theoretical criticism applies to the aptness of our most common AMR metaphor themes.

War against resistance, infections and microbes

War metaphors typically evoke a helpful sense of urgency and a need for action (Flusberg, Matlock, and Thibodeau 2017, 2018; Nerlich 2009). Yet numerous theoretical problems have been identified, which question the aptness of war metaphors for communicating relevant information about AMR. War metaphors fail to capture the ecological nature of AMR (Institute of Medicine (US) Forum on Microbial Threats 2006; Maccaro 2021; Nerlich 2009), and ignore the issue of ever-evolving resistance, which is incongruous with the limited nature of one-off battles. The portrayal of humans and microbes as enemies fails to convey the subtle nuances of human relationships with bacteria, many of which are symbiotic (Murray et al. 2016) and vital to human survival, such as their role in digestion and immunity. Related assumptions about strictly dichotomous roles of *winners* and *losers* may result in several problematic consequences. Given the immense number of microbial species and their remarkable ability to adapt to environmental pressures, microbes would most certainly emerge as winners in the presumed *combat* with humanity, thereby sending a bleak message to anybody wishing to join the *fight* (ReAct 2015). The *winner/loser* dichotomy could also trigger unhelpful mental imagery in patients. Individuals might identify as *losers* if their recovery from infection is slower than anticipated. This is supported by previous research on metaphor use in cancer communication, where a lack of recovery was often interpreted as personal *defeat* and accompanied by emotions of guilt (Hendricks et al. 2018; Olza et al. 2021).

A ReAct project publication observed that 'human beings cannot go to "war" with global warming' (ReAct 2016). Similarly, it seems absurd to declare warfare on the abstract threat of AMR. War metaphors, by signalling the need for active solutions, also discourage the uptake of behavioural alternatives (cf. Hauser and Schwarz 2015). In the context of COVID-19, war

metaphors were criticised for discouraging passive solutions of self-restraint such as social distancing and shielding during different stages of lockdown (Olza et al. 2021). A similar concern applies in the context of AMR, where war metaphors may overemphasise the need for active solutions such as antibiotic development while neglecting the value of passive approaches, such as refraining from antibiotic overuse.

A final concern regarding war metaphors is the negative light that might be cast onto areas where action against AMR is deemed insufficient. Blame might be attributed to low-and middle-income countries, where a lack of resources can lead to overuse of antibiotics (Kamenshchikova et al. 2023), or even specific medical specialities, where the appropriate use of antibiotics is called into question.

Heroes and villains of AMR

Metaphors contained within the theme of heroes and villains share some of the theoretical problems discussed under the previous theme of war. The portrayal of two opposing sides, namely the *evil menace of omnipotent superbugs* and the *benign or heroic superpower of antibiotics* creates an unrealistic and unhelpful expectation of winners and losers in a finite struggle or confrontation. Qualitative investigations conducted by the Wellcome Trust (2019) suggested that lay populations outside the UK and US struggled to associate meaning with the commonly used term *superbug* and questioned its overall credibility. Additionally, the metaphorical vilification of microbes as bearers of disease or death may be inapt or misleading given the vast and diverse number of microbes, many of which are not only inseparable from human life but indeed confer huge benefits to essential biological mechanisms of the human body (ReAct 2015). A key example is the complex human gut microbiota, where the composition of intestinal bacteria has been linked to neurological functioning and mental health (Shoubridge et al. 2022). Similarly, unreserved praise for or glorification of antibiotics fails to take into account the often dangerous side effects of these medicines (D'Achille and Morroni 2023; Elvers et al. 2020). Rather than presenting dual forces of good and evil, community work by the ReAct global network aimed to 're-imagine resistance' as a *balance* or *dance* between different, yet intertwined entities with the goal of building a mutually convenient community or relationship (ReAct 2015).

Post-antibiotic apocalypse and looming crisis of AMR

Doomsday metaphors, encompassing fictitious crisis or apocalyptic imagery, are likely effective for drawing attention (Nerlich 2009). Indeed, recent experimental data suggest that showing members of the public information films depicting an alarming post-antibiotic future (i.e. the WHO information film 'Catch') may help to lower people's expectations about the power of antibiotics (Sirota and Juanchich 2024). Yet, scholars have warned that the sensationalist nature of some apocalyptic messaging may induce a number of counterproductive reactions (Servitje 2019). Overly alarmist, fear-invoking discourse can lead to paralysis or sense of inevitable doom, thus discouraging any positive behaviour change (Wellcome Trust 2019). Overly fantastical accounts of AMR, previously dubbed as the 'Star Wars of microbiology', are unlikely to resonate with the general population, whose concerns lie with overcoming the struggles of daily life (McCall et al. 2023). Similarly, the 'discursive overbidding' of newspapers competing for readership, may lead to an eventual blunting of people's perceptions (Nerlich 2009).

Silent, creeping threat of AMR

The metaphorical framing of AMR as imperceptible, slow-moving threat reflects public perceptions around the acuteness of the challenge. Indeed, AMR falls into the category of perpetual problems, where a gradual worsening results in low salience and de-prioritisation on global media and policy agendas (Staupe-Delgado and Rubin 2023). It is questionable whether the

open labelling of AMR as an imperceptible threat can help to overturn existing perceptions and increase overall awareness. A recent empirical study tested the effects of labelling AMR as 'silent' (Sirota 2024). Comparing health messages with AMR described as either 'silent pandemic' or 'pandemic', the author found no significant differences in participants' risk perceptions. Critically, when participants were provided with more information about the rationale behind the chosen terms (e.g. 'it quietly and gradually spreads around the world receiving less attention than it should'), risk ratings for 'silent pandemic' actually decreased. It thus appears that framing AMR as 'silent' should be avoided to prevent depreciating effects on AMR risk perceptions.

Policy implications and recommendations

Previous research suggests that metaphors can be an effective tool for risk communication, especially in the context of an abstract and complex topic such as AMR. Our results provide evidence for the high frequency and diversity of metaphorical language in global AMR discourse. Yet our thematic analysis of existing AMR discourse reveals several concerning issues related to (1) a high degree of conventionality, (2) a low level of systemicness, meaning the metaphors confer little explanatory value or specific knowledge about AMR, and (3) a frequent mixing of different metaphors, meaning they likely fail to conjure consistent mental models. Additionally, our theoretical appraisal illuminated several critical problems pertaining to the aptness of the most common metaphorical themes.

Our results indicate an urgent need for policy makers, health officials, and members of the media to re-consider current use of figurative language across national AMR action plans, as well as public-facing communication materials such as campaign leaflets and informational films. Metaphors are never neutral, and careful consideration of the chosen source domains and overall communication themes is essential for successful communication (Potts and Semino 2019). Re-framing of AMR can be done successfully, with a pioneering example set by a mobile video game (Servitje 2019), where thinking was shifted from warfare to an appreciation of human-microbial co-existence. Empirical tests of metaphor effectiveness similar to Sirota's (2024) investigation of the term 'silent pandemic' will be essential for avoiding unexpected metaphorical framing effects (Flusberg et al. *in press*). Deliberate and conscious metaphor choices should follow a number of key principles:

- Choose single, novel metaphors drawn from universally meaningful and familiar source domains.
- Choose metaphors with systemic mappings that confer specific knowledge to address pervasive public misunderstandings, for example pertaining to the ineffectiveness of antibiotics for viral infections or the development of resistance within bacteria as opposed to the human body.
- Choose apt metaphorical mappings, which communicate something relevant about the target domain of AMR. Avoid relying on existing, conventional and theoretically problematic metaphors referring to warfare, heroes and villains (most notably 'superbugs'), the post-antibiotic apocalypse and the silent threat of AMR.

Conclusions

Leveraging metaphors in AMR risk communications could be a fruitful approach for making a complex topic more accessible to lay audiences. Current global public discourse is rife with metaphor, but existing metaphors are theoretically problematic, for example due to painting a misleading picture of a finite struggle between good and evil. Almost all existing metaphors are highly emotive (e.g. aiming to evoke a sense of urgency and doom). They aim to raise awareness about the risk of AMR rather than communicate specific knowledge. Additionally, most existing

metaphors are highly conventional, thereby questioning their suitability for offering novel insights into the global challenge of AMR. In light of these shortcomings, there is an urgent need to develop and test theoretically informed, novel metaphors that are specific to the context of AMR. Ideally, these novel metaphors will use systemic mappings to communicate relevant knowledge about drug resistance and infections as well as appropriate behaviours to curb AMR.

Acknowledgements

The authors gratefully acknowledge the comments and materials received from Satya Sivaraman, Communications Coordinator at ReAct Asia Pacific.

Ethics statement

Ethical approval was obtained from the University of Leicester Medical and Biological Sciences Research Ethics Committee [Project ID: 1202].

Author contributions

Eva Krockow: Conceptualisation, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing. Meghann Jones: Data curation, Investigation, Project administration, Writing – review & editing. Carolyn Tarrant: Conceptualisation, Formal analysis, Methodology, Writing – review & editing. Marc Mendelson: Formal analysis, Writing – review & editing. Stephen Flusberg: Conceptualisation, Formal analysis, Methodology, Writing – review & editing.

Open access

For the purpose of open access, the authors have applied a Creative Commons Attribution licence (CC BY) to any Author Accepted Manuscript version arising from this submission.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

A detailed data file with information about all metaphors extracted, their respective sources, and thematic codes, is available in the [Supplementary Appendix](#) and from the OSF [<https://osf.io/2ng5z/>]. Due to the personally identifiable nature of social media data, the metaphors extracted from our social media search are excluded from this data file. We have included some quotations of social media contents in our results section, but have ensured that these quotations were taken from contents posted by official organisations as opposed to individual users.

References

- Bostrom, A. 2008. "Lead Is like Mercury: Risk Comparisons, Analogies and Mental Models." *Journal of Risk Research* 11 (1): 99–117. <https://doi.org/10.1080/13669870701602956>.
- Bouchoucha, S. L., E. Whatman, and M. J. Johnstone. 2019. "Media Representation of the Antimicrobial Resistance (AMR) Crisis: An Australian Perspective." *Infection, Disease & Health* 24 (1): 23–31. <https://doi.org/10.1016/j.idh.2018.09.084>.
- Bowdle, B. F., and D. Gentner. 2005. "The Career of Metaphor." *Psychological Review* 112 (1): 193–216. <https://doi.org/10.1037/0033-295X.112.1.193>.
- Brookes-Howell, L., G. Elwyn, K. Hood, F. Wood, L. Cooper, H. Goossens, M. Leven, and C. C. Butler. 2012. "The Body Gets Used to Them: Patients' Interpretations of Antibiotic Resistance and the Implications for Containment Strategies." *Journal of General Internal Medicine* 27 (7): 766–772. <https://doi.org/10.1007/s11606-011-1916-1>.

- Brown, B., and P. Crawford. 2009. "Post Antibiotic Apocalypse: Discourses of Mutation in Narratives of MRSA." *Sociology of Health & Illness* 31 (4): 508–524. <https://doi.org/10.1111/j.1467-9566.2008.01147.x>.
- Brugman, B. C., C. Burgers, and G. J. Steen. 2017. "Recategorizing Political Frames: A Systematic Review of Metaphorical Framing in Experiments on Political Communication." *Annals of International Communication Association* 41 (2):181–197.
- Bruine de Bruin, W., K. G. Carman, and A. M. Parker. 2021. "Mental Associations with COVID-19 and How They Relate with Self-Reported Protective Behaviors: A National Survey in the United States." *Social Science & Medicine* 275: 113825. <https://doi.org/10.1016/j.socscimed.2021.113825>.
- Cannon, G. 1995. *Superbug—Nature's Revenge: Why Antibiotics Can Breed Disease*. London: Virgin Publishing Ltd.
- Chukwu, E. E., D. A. Oladele, O. B. Awoderu, E. E. Afocha, R. G. Lawal, I. Abdus-Salam, F. T. Ogunsola, and R. A. Audu. 2020. "A National Survey of Public Awareness of Antimicrobial Resistance in Nigeria." *Antimicrobial Resistance & Infection Control* 9:1–10. <https://doi.org/10.1186/s13756-020-00739-0>.
- Crawford, P., B. Brown, B. Nerlich, and N. Koteyko. 2008. "The 'Moral Careers' of Microbes and the Rise of the Matrons: An Analysis of UK National Press Coverage of Methicillin-Resistant Staphylococcus aureus (MRSA) 1995–2006." *Health, Risk & Society* 10 (4): 331–347. <https://doi.org/10.1080/13698570802167397>.
- D'Achille, G., and G. Morroni. 2023. "Side Effects of Antibiotics and Perturbations of Mitochondria Functions." *International Review of Cell and Molecular Biology* 377: 121–139.
- Davies, S. 2021. *Preventing Global Health Crises: An Interview with Dame Sally Davies*. Edited by Hemant Ahlawat and Mitch Cuddihy. McKinsey & Company. <https://www.mckinsey.com/industries/social-sector/our-insights/preventing-global-health-crises-an-interview-with-dame-sally-davies#/>
- Department of Health and Social Care. 2021. *New Campaign to 'Stop COVID-19 Hanging Around*. GOV.UK. <https://www.gov.uk/government/news/new-campaign-to-stop-covid-19-hanging-around#:~:text=Part%20of%20a%20wider%20campaign,in%20relation%20to%20COVID%2D19.>
- Elvers, K. T., V. J. Wilson, A. Hammond, L. Duncan, A. L. Huntley, A. D. Hay, and E. T. Van Der Werf. 2020. "Antibiotic-Induced Changes in the Human Gut Microbiota for the Most Commonly Prescribed Antibiotics in Primary Care in the UK: A Systematic Review." *BMJ Open* 10 (9): E 035677. <https://doi.org/10.1136/bmjopen-2019-035677>.
- Fitzpatrick, F., C. Tarrant, V. Hamilton, F. M. Kiernan, D. Jenkins, and E. M. Krockow. 2019. "Sepsis and Antimicrobial Stewardship: Two Sides of the Same Coin." *BMJ Quality & Safety* 28 (9): 758–761. <https://doi.org/10.1136/bmjqs-2019-009445>.
- Flick, U. 2013. *The SAGE Handbook of Qualitative Data Analysis*. London, United Kingdom: SAGE.
- Flusberg, S. J., K. J. Holmes, P. H. Thibodeau, R. L. Nabi, and T. Matlock. in press. "The Psychology of Framing: How Everyday Language Shapes the Way We Think, Feel, and Act." *Psychological Science in the Public Interest*. 25 (3): 105–161. <https://doi.org/10.1177/15291006241246966>
- Flusberg, S. J., A. Mackey, and E. Semino. 2024. "Seatbelts and Raincoats, or Banks and Castles: Investigating the Impact of Vaccine Metaphors." *PLoS One* 19 (1): e0294739. <https://doi.org/10.1371/journal.pone.0294739>.
- Flusberg, S. J., T. Matlock, and P. H. Thibodeau. 2017. "Metaphors for the War (or Race) against Climate Change." *Environmental Communication* 11 (6): 769–783. <https://doi.org/10.1080/17524032.2017.1289111>.
- Flusberg, S. J., T. Matlock, and P. H. Thibodeau. 2018. "War Metaphors in Public Discourse." *Metaphor and Symbol* 33 (1): 1–18. <https://doi.org/10.1080/10926488.2018.1407992>.
- Flusberg, S. J., and P. H. Thibodeau. 2023. "Why Is Mother Earth on Life Support? Metaphors in Environmental Discourse." *Topics in Cognitive Science* 15 (3): 522–545. <https://doi.org/10.1111/tops.12651>.
- Galesic, M., and R. Garcia-Retamero. 2013. "Using Analogies to Communicate Information about Health Risks." *Applied Cognitive Psychology* 27 (1): 33–42. <https://doi.org/10.1002/acp.2866>.
- Gallagher, L., J. McAuley, and M. G. Lorimer. 2013. "A Randomized-Controlled Trial of Using a Book of Metaphors to Reconceptualize Pain and Decrease Catastrophizing in People With Chronic Pain." *The Clinical Journal of Pain* 29 (1): 20–25. <https://doi.org/10.1097/AJP.0b013e3182465cf7>.
- Govindan, B. 2018. "Bacterial Survivor: An Interactive Game That Combats Misconceptions about Antibiotic Resistance." *Journal of Microbiology & Biology Education* 19 (3):1–3. <https://doi.org/10.1128/jmbe.v19i3.1675>.
- Group, P. 2007. "MIP: A Method for Identifying Metaphorically Used Words in Discourse." *Metaphor and Symbol* 22 (1): 1–39. <https://doi.org/10.1080/10926480709336752>.
- Guy, S., Y. Kashima, I. Walker, and S. O'Neill. 2013. "Comparing the Atmosphere to a Bathtub: Effectiveness of Analogy for Reasoning about Accumulation." *Climatic Change* 121 (4): 579–594. <https://doi.org/10.1007/s10584-013-0949-3>.
- Hart, C. 2021. "Animals vs. Armies: Resistance to Extreme Metaphors in anti-Immigration Discourse." *Journal of Language and Politics* 20 (2): 226–253. <https://doi.org/10.1075/jlp.20032.har>.
- Harvey, F. 2019. "Antibiotic Resistance as Big a Threat as Climate Change – Chief Medic." *The Guardian*. April 29 2019, <https://www.theguardian.com/society/2019/apr/29/antibiotic-resistance-as-big-threat-climate-change-chief-medic-sally-davies>
- Hauser, D. J., and N. Schwarz. 2015. "The War on Prevention: Bellicose Cancer Metaphors Hurt (Some) Prevention Intentions." *Personality & Social Psychology Bulletin* 41 (1): 66–77. <https://doi.org/10.1177/0146167214557006>.

- Hendricks, R. K., Z. Demjén, E. Semino, and L. Boroditsky. 2018. "Emotional Implications of Metaphor: Consequences of Metaphor Framing for Mindset about Cancer." *Metaphor and Symbol* 33 (4): 267–279. <https://doi.org/10.1080/10926488.2018.1549835>.
- Hsieh, H.-F., and S. E. Shannon. 2005. "Three Approaches to Qualitative Content Analysis." *Qualitative Health Research* 15 (9): 1277–1288. <https://doi.org/10.1177/1049732305276687>.
- Institute of Medicine (US) Forum on Microbial Threats. 2006. *Ending the War Metaphor: The Changing Agenda for Unraveling the Host-Microbe Relationship*. Washington, DC: National Academies Press (US).
- James, R. 2005. "Battling Bacteria." In *Vision Magazine*. University of Nottingham.
- Kamenshchikova, A., P. F. Wolffs, C. J. Hoebe, J. Penders, and K. Horstman. 2023. "Metaphors of Foreign Strangers: Antimicrobial Resistance in Biomedical Discourses." *Science as Culture* 32 (2): 294–314. <https://doi.org/10.1080/09505431.2023.2180628>.
- Koteyko, N., B. Nerlich, P. Crawford, and N. Wright. 2007. "Not Rocket Science' or 'No Silver Bullet'? Media and Government Discourses about MRSA and Cleanliness." *Applied Linguistics* 29 (2): 223–243. <https://doi.org/10.1093/applin/amn006>.
- Krockow, E. M. 2020. "Nomen Est Omen: Why We Need to Rename 'Antimicrobial Resistance.'" *JAC-Antimicrobial Resistance* 2 (3): dlaa067. <https://doi.org/10.1093/jacamr/dlaa067>.
- Krockow, E. M., K. O. Cheng, J. Maltby, and E. McElroy. 2023. "Existing Terminology Related to Antimicrobial Resistance Fails to Evoke Risk Perceptions and be Remembered." *Communications Medicine* 3 (1): 149. <https://doi.org/10.1038/s43856-023-00379-6>.
- Lakoff, G., and M. Johnson. 1980. *Metaphors We Live By*. Chicago, Illinois, USA: University of Chicago Press.
- Landau, M. J., J. Arndt, and L. D. Cameron. 2018. "Do Metaphors in Health Messages Work? Exploring Emotional and Cognitive Factors." *Journal of Experimental Social Psychology* 74: 135–149. <https://doi.org/10.1016/j.jesp.2017.09.006>.
- Larson, B. M. H., B. Nerlich, and P. Wallis. 2005. "Metaphors and Biorisks: The War on Infectious Diseases and Invasive Species." *Science Communication* 26 (3): 243–268. <https://doi.org/10.1177/1075547004273019>.
- Maccaro, J. 2021. "Be Mindful of Your Metaphors about Microbes." *mSphere* 6 (3): e00431-00421. <https://doi.org/10.1128/mSphere.00431-21>.
- McCall, B., L. Shallcross, M. Wilson, and A. Hayward. 2023. "Making Microbes Matter: Storytelling's Potential to Make Antibiotic Resistance Real and Relevant to the Public." *NPJ Antimicrobials and Resistance* 1 (1):1–5. <https://doi.org/10.1038/s44259-023-00012-5>.
- Mendelson, M., M. Balasegaram, T. Jinks, C. Pulcini, and M. Sharland. 2017. "Antibiotic Resistance Has a Language Problem." *Nature* 545 (7652): 23–25. <https://doi.org/10.1038/545023a>.
- Mokoena, T. T., N. Schellack, and A. J. Brink. 2021. "Driving Antibiotic Stewardship Awareness through the Minibus-Taxi Community across the Tshwane District, South Africa—A Baseline Evaluation." *JAC - Antimicrobial Resistance* 3 (3):1–6.
- Montgomery, S. L. 1991. "Codes and Combat in Biomedical Discourse." *Science as Culture* 2 (3): 341–390. <https://doi.org/10.1080/09505439109526314>.
- Mufflih, S. M., S. Al-Azzam, R. A. Karasneh, B. R. Conway, M., and A. Aldeyab. 2021. "Public Health Literacy, Knowledge, and Awareness Regarding Antibiotic Use and Antimicrobial Resistance during the COVID-19 Pandemic: A Cross-Sectional Study." *Antibiotics* 10 (9): 1107. <https://doi.org/10.3390/antibiotics10091107>.
- Murray, C. J. L., K. S. Ikuta, F. Sharara, L. Swetschinski, G. Robles Aguilar, A. Gray, C. Han, et al. 2022. "Global Burden of Bacterial Antimicrobial Resistance in 2019: A Systematic Analysis." *The Lancet* 399 (10325): 629–655. [https://doi.org/10.1016/S0140-6736\(21\)02724-0](https://doi.org/10.1016/S0140-6736(21)02724-0).
- Murray, M., S. Sivaraman, K. Calle, J. Spiegel, J. DeBoos, A. Yassi, and A. Quizpé. 2016. "Fear, Wonder and Learning: Reimagining the Human-Microbe Story." *Antennae* 36: 104–133.
- Musolff, A., and J. Zinken. 2009. *Metaphor and Discourse*. London, United Kingdom: Palgrave Macmillan.
- Nerlich, B. 2009. "The Post-Antibiotic Apocalypse" and the "War on Superbugs": Catastrophe Discourse in Microbiology, Its Rhetorical Form and Political Function." *Public Understanding of Science* 18 (5): 574–590. <https://doi.org/10.1177/0963662507087974>.
- Naghavi, M., S. E. Vollset, K. S. Ikuta, L. R. Swetschinski, A. P. Gray, E. E. Wool, G. R. Aguilar, et al. 2024. "Global Burden of Bacterial Antimicrobial Resistance 1990–2021: A Systematic Analysis with Forecasts to 2050." *The Lancet*. 404 (10459): 1199–1226.
- Nerlich, B., and N. Koteyko. 2009. MRSA —Portrait of a Superbug: A Media Drama in Three Acts. In: Musolff, A., Zinken, J. (eds) *Metaphor and Discourse* (pp. 153-169). Palgrave Macmillan, London. https://doi.org/10.1057/9780230594647_10
- Olza, I., V. Koller, I. Ibarretxe-Antuñano, P. Pérez-Sobrino, and E. Semino. 2021. "The #ReframeCovid Initiative From Twitter to Society via Metaphor." *Metaphor and the Social World* 11 (1): 98–120. <https://doi.org/10.1075/msw.00013.olz>.
- Peters, J., N. Dykes, M. Habermann, C. Ostgathe, and M. Heckel. 2019. "Metaphors in German Newspaper Articles on Multidrug-Resistant Bacteria in Clinical Contexts, 1995–2015: A Computer-Assisted Study." *Metaphor and the Social World* 9 (2): 221–241. <https://doi.org/10.1075/msw.18006.pet>.

- Potts, A., and E. Semino. 2019. "Cancer as a Metaphor." *Metaphor and Symbol* 34 (2): 81–95. <https://doi.org/10.1080/10926488.2019.1611723>.
- ReAct. 2015. *Microbes and Metaphors: A Dialogue between Scientists, Artists and Activists*. Uppsala, Sweden: The Reimagining Resistance Group.
- ReAct. 2016. *Reimagining Resistance: Towards a New Paradigm of Human-Bacterial Relations*. Edited by S. Sivaraman and M. Murray. Uppsala, Sweden: Reimagining Resistance: The Reimagining Resistance Group.
- Rodehau-Noack, J. 2021. "War as Disease: Biomedical Metaphors in Prevention Discourse." *European Journal of International Relations* 27 (4): 1020–1041. <https://doi.org/10.1177/13540661211055537>.
- Rush, L., C. Patterson, L. McDaid, and S. Hilton. 2019. "Communicating Antimicrobial Resistance and Stewardship in the National Press: Lessons from Sepsis Awareness Campaigns." *The Journal of Infection* 78 (2): 88–94. <https://doi.org/10.1016/j.jinf.2018.09.001>.
- Semino, E. 2021. "Not Soldiers but Fire-Fighters" – Metaphors and Covid-19." *Health Communication* 36 (1): 50–58. <https://doi.org/10.1080/10410236.2020.1844989>.
- Servitje, L. 2019. "Gaming the Apocalypse in the Time of Antibiotic Resistance." *The University of Chicago Press Journals, Osiris*, 34 (1): 316–337.
- Servitje, L. 2021. "The Not-So-Strange Case of Dr. Jekyll and Mr. Hyde in Antibiotic Research: An Interdisciplinary Opportunity." *Antibiotics* 10 (1):1–11.
- Shoubridge, A. P., J. M. Choo, A. M. Martin, D. J. Keating, M. Wong, J. Licinio, and G. B. Rogers. 2022. "The Gut Microbiome and Mental Health: Advances in Research and Emerging Priorities." *Molecular Psychiatry* 27 (4): 1908–1919. <https://doi.org/10.1038/s41380-022-01479-w>.
- Singh-Phulgenda, S., P. Antoniou, D. L. F. Wong, K. Iwamoto, and K. Kandelaki. 2023. "Knowledge, Attitudes and Behaviors on Antimicrobial Resistance among General Public across 14 Member States in the WHO European Region: Results from a Cross-Sectional Survey." *Frontiers Public Health* 11:1–19.
- Sirota, M. 2024. "Should We Stop Referring to the Pandemic of Antimicrobial Resistance as Silent?" *JAC-Antimicrobial Resistance* 6 (1): dlae018. <https://doi.org/10.1093/jacamr/dlae018>.
- Sirota, M., and M. Juanchich. 2024. "Seeing an Apocalyptic Post-Antibiotic Future Lowers Antibiotics Expectations and Requests." *Communications Medicine* 4 (1): 141. <https://doi.org/10.1038/s43856-024-00567-y>.
- Sopory, P., and J. P. Dillard. 2002. "The Persuasive Effects of Metaphor: A Meta-Analysis." *Human Communication Research* 28 (3): 382–419. <https://doi.org/10.1111/j.1468-2958.2002.tb00813.x>.
- Staupe-Delgado, R., and O. Rubin. 2023. "What Makes an Acute Emergency? Temporal Manifestation Patterns and Global Health Emergencies." *Third World Quarterly* 44 (8): 1790–1806. <https://doi.org/10.1080/01436597.2023.2208031>.
- Thibodeau, P. H., and L. Boroditsky. 2011. "Metaphors We Think with: The Role of Metaphor in Reasoning." *PLoS One* 6 (2): e16782. <https://doi.org/10.1371/journal.pone.0016782>.
- Thibodeau, P. H., and F. H. Durgin. 2011. "Metaphor Aptness and Conventionality: A Processing Fluency account." *Metaphor and Symbol* 26 (3): 206–226. <https://doi.org/10.1080/10926488.2011.583196>.
- Thibodeau, P. H., R. K. Hendricks, and L. Boroditsky. 2017. "How Linguistic Metaphor Scaffolds Reasoning." *Trends in Cognitive Sciences* 21 (11): 852–863. <https://doi.org/10.1016/j.tics.2017.07.001>.
- Thibodeau, P. H., T. Matlock, and S. J. Flusberg. 2019. "The Role of Metaphor in Communication and Thought." *Language and Linguistics Compass* 13 (5): 1–18. <https://doi.org/10.1111/lnc3.12327>.
- Van Stee, S. K. 2018. "Meta-Analysis of the Persuasive Effects of Metaphorical vs. Literal Messages." *Communication Studies* 69 (5): 545–566. <https://doi.org/10.1080/10510974.2018.1457553>.
- Washer, P., and H. Joffe. 2006. "The "Hospital Superbug": Social Representations of MRSA." *Social Science & Medicine* 63 (8): 2141–2152. <https://doi.org/10.1016/j.socscimed.2006.05.018>.
- Wellcome Trust. 2019. *Reframing Resistance How to Communicate about Antimicrobial Resistance Effectively*. London, United Kingdom: Wellcome Trust.
- WHO (World Health Organization). 2015. *Antibiotic Resistance: Multi-Country Public Awareness Survey*. Geneva, Switzerland: WHO Report.
- Zinken, J., I. Hellsten, and B. Nerlich. 2008. "Discourse Metaphors." In *Body, Language and Mind Volume 2: Sociocultural Situatedness (Cognitive Linguistics Research 35-2)*, edited by R. M. Frank, R. Driven, T. Ziemke, and E. Bernárdez. Berlin/New York:de Gruyter. 363–385