A Scoping Review on the Influential Cognitive Constructs informing public AMR behavior compliance and the attribution of personal responsibility

Abstract

Background: Antibiotic resistance is a growing threat to public health. Despite various attempts at educating the public on AMR and judicial antibiotic use, fallacies and misconceptions remain. To successfully promote behavior change, various cognitive constructs pertaining to antibiotic behavior need to be identified and targeted.

Methods: Using the Arksey and O'Malley (2005) methodological framework, a credible reflexive examination of literature was conducted, permitting identification of a breadth of literature that pertained to the influence of cognitive constructs on public antimicrobial behavior.

Results: From 393 abstracts identified, 67 full articles were screened, and 43 papers were chosen for review. Three themes were identified (1) sociodemographic influences, (2) knowledge, misconceptions and fallacies, and (3) public attitudes and the social influence of friends and family. Geographical location, education level, cognitive dissonance, and social norms were found to influence AMR cognition, resulting in disproportionate risk assessments that are facilitated by social information brokering.

Conclusion: Public AMR resilience, responsibility, and behavior compliance are influenced by cognitive constructs, which are liable to the appropriation of misconceptions, fallacies and social behavior models obtained via information brokering. A cohesive multi-disciplinary participatory approach to AMR management and interventional design that applies the influence of cognitive constructs to inform public AMR behavior compliance is recommended.

Keywords: Antibiotic, Beliefs, Attitudes, Knowledge, Expectations, Education

Background

Used to treat and prevent bacterial infections, antibiotics revolutionized healthcare as they improved mortality rates globally. While considered beneficial to public health, sustained global demand and misuse positively correlate with an accelerated advancement of antimicrobial resistance (AMR) [1]. AMR can render a previously successful treatment ineffective, limiting treatment options by increasing: the risk of spreading resistant microorganisms to others, healthcare costs, duration of treatment, and mortality [2]. Presently, it is reported that between 8–35 % of antibiotics prescribed globally are not medically justified [3, 4], while the rates for public self-medication can only be inferred. Current global estimates predict that by 2050, AMR will cause 10 million deaths a

year and cost healthcare trillions of dollars [5]. Therefore, multifaceted global efforts to ensure antibiotic viability are essential to public health and clinical practice.

In order to sustain antimicrobial viability policymakers and global healthcare institutions have utilized various management strategies and health promotion campaigns aimed at addressing antibiotic behavior e.g. Be Antibiotic Aware: Smart use, Best care [3]. Antibiotic behavior is typically classified as either pertaining to healthcare professionals (HCP) or the public. However, while HCP conduct determines antimicrobial prescribing, patient expectations and satisfaction can influence misuse by HCPs [6]. Likewise, where public expectations for prescriptions are not met, patients re-consult or rely on the internet to self-diagnose [7, 8]. Though, public behavior also includes non-judicial usage, where they self-medicate with antibiotics they had stored, brokered or purchased without consulting a HCP [9]. In turn, the question of responsibility towards AMR arises, is it the responsibility of policymakers and HCP, or could it be argued that individuals and communities hold responsibility for limiting AMR. Public AMR campaigns evaluated in the literature focus on providing AMR education and the need for compliant antimicrobial stewardship (AMS) behavior; currently what are typically researched and measured is understanding, information giving, knowledge transfer and community engagement [10]. Although, the promotion of correct antibiotic use via patient educational material does not guarantee successful information transfer or behavior change [11]. While some success has been found in reducing the number of antibiotic prescriptions issued or the prevalence of resistant microbial infections, variations within and between populations exist [5,9]. A recent systematic review [12] on public AMR knowledge and beliefs found that the public held various misconceptions, inconsistent knowledge, and held unrealistic beliefs that they do not personally contribute to AMR or its solution despite potential exposure to numerous AMR educational campaigns; suggesting current interventional design is insufficient to promote the attribution of personal risk and sustained behavior change, as other factors influence public behavior compliance. The justification for this review is to demonstrate that a more eclectic approach to the understanding of behavior change vis-à-vis public AMR behavior is imperative.

As has been previous evidenced by Fletcher-Miles et al. [10], there is a lack of theoretical underpinning towards public interventional design in literature and a paucity of interventional studies that examine cognition and cognitive constructs which influence public behavior in relation to AMR. Cognition is recognized as fundamental in behavior change where there is an interplay of various internal or external influences on human thought such as

knowledge, beliefs or culture. Termed cognitive constructs, these influences inform behavioral risk assessments, subsequent attitudes and behavior displays [13]. Ajzen [14] would suggest that individual health-related behavior change can be predicted based on cognitive constructs' attitudes, intentions, social norms and perceptions of behavior control. While the provision of AMR knowledge can contribute towards informing public behavior, it is only one cognitive construct that influences public compliance. In support of this, Belongia et al. [15] longitudinal study found cognitive constructs such as beliefs and social norms can impact public behavior pertaining to AMR. Likewise, Abujheisha et al. [11] found irrespective of AMR knowledge held, a prevalence of self-medication or brokering within a community is facilitated by a person's previous experience and access to antibiotics, demonstrating the significance of cognitive constructs in behavior change. Consequently, if behavior change is to be sustained and impactful then appreciation of personal attribution of responsibility derived from cognitive constructs such as beliefs, attitudes, expectations, social norms, self-efficacy [16], all become critical factors that need to be considered for interventional design to provide a holistic approach to behavioral compliance and change [17].

Methods

This review seeks to identify current literature that outline findings towards the cognitive constructs that may influence AMR behavior, in order to gain insight on the public's perspective of AMR behavioral compliance and attribution of personal responsibility. The increasingly popular scoping review method was selected as it permitted identification and evaluation of literature using various designs and methodologies, to identify gaps in the existing literature to inform future research and current debate. To ensure credible and reflexive examination of the literature the Arksey and O'Malley [18] methodological framework was used as outlined below, to ensure rigor, transparency, validation, and replication of the current findings.

Identifying the Research Questions

1. What cognitive constructs influence collective public AMR behavior?
2. Do cognitive constructs contribute to the attribution of personal risk to AMR and subsequent behavior compliance?
3. Are there other factors that influence individual behavior constructs vis-à-vis AMR?

Identifying Relevant Literature,

Search Strategy

An electronic database search was performed using PubMed, Medline and ASSIA databases. A Boolean search research strategy was devised to ensure variations in global spelling and terms were accommodated using the keywords: AMR/antimicrobial resistance, antibiotic resistance, antibiotics, public, beliefs/expectations/ attitudes/knowledge/cognition. The reference lists and related articles for identified papers were also hand-searched; while grey literature was not actively sought, it was not excluded if identified at this time.

Inclusion criteria

In line with the introduction of the World Health Organisations global strategy for containment of AMR [19] and previous research [10], papers published between 1999 to July 2019 were sought for inclusion. Due to budget and time constraints, only papers written in English that captured public cognitive constructs pertaining to human AMR behavior were included. While empirical research was sought, no assessment of scientific validity or statistical power calculations were used to inform inclusion.

Exclusion criteria

Papers pertaining specifically to HCPs, animals, or those that did not meet the research questions were excluded as the focus of this review is the influence of cognitive constructs on public behavior.

Study Selection

Following the inclusion criteria, 393 papers were identified. The abstracts of these papers were then screened to meet the research questions, identifying 67 papers as relevant to the research questions. On review, a further 24 papers were excluded as they did not meet inclusion criteria, leaving 43 articles for review.

Charting the data

All articles were synthesized and charted using the following categorizations: authors and year, country, aim, study population, number of participants, method, key findings and reviewer noted themes based on a narrative approach (See Appendix A).

Collating, summarizing and reporting the results

After individually reviewing the articles for inclusion, the authors came together to discuss the key findings and noted themes. Findings were then collated and charted alphabetically by author, noting any influence on behavior and the identified themes (see appendix A).

Results

Following the method outlined above [18], forty-three qualitative [20-28], quantitative [7, 8, 11, 29-58] or mixed methods [59] studies were selected for review, as they captured cognitive constructs influencing public antibiotic use, attribution of personal responsibility and AMR behavior compliance from a global community. As outlined in *Appendix 1*, using a narrative approach each author primarily screened the selected literature, before coming together to reach a consensus on three themes that encapsulated cognitive constructs influencing public behavior: sociodemographic influences, knowledge, misconceptions and fallacies, and, public attitudes and social influence.

Sociodemographic influences

Within the literature identified, it was commonly accepted that attained levels of AMR knowledge were representative of appropriate antibiotic behavior; supporting the inclusion of knowledge as a cognitive construct influencing public behavior. However, 20% of the studies reviewed [26, 35, 36, 40, 43, 49, 51, 56, 58] identified an influence of sociodemographic categorizations on the level of AMR knowledge held by the public and subsequent behavioral displays. Predominately, 87% of these studies [35, 36, 40, 49, 51, 56, 58] found that participant education level positively influenced the level of AMR/ antibiotic knowledge reported; those with higher levels of education had higher knowledge of AMR. In turn these findings suggest public behavior compliance is reliant on an individual's edification, which was assessed and supported by two of the studies reviewed [49, 58]. Moreover, Van Hecke et al [27] reported the public can sometimes fail to comprehend interventional messages; their participants suggested that more accessible messages towards AMR would work towards increasing their knowledge and compliant behavior.

Geographical location [35, 36, 43] was the second sociodemographic influence on cognitive constructs pertaining to AMR identified. Differences in public behavior were found between [43] and within [35, 36,] countries. Only one study identified [43] compared public AMR behavior between countries. Unsurprisingly, they found that country wealth positively predicted judicial antibiotic dispensary and behavior compliance, as developed countries typically have

developed healthcare infrastructure and legislation that manages antibiotic availability to public demand. In countries where legislation and infrastructure are laxer, antibiotic availability is increased, which in turn was found to influences non-judicial usage by five of the studies identified [28, 46, 53, 54]. Although while participants from less wealthy countries were more likely to hold inaccurate AMR knowledge [28, 53, 54], those from a wealthy country were found to misuse based on availability, irrespective of higher AMR knowledge [46] suggesting that while healthcare infrastructure and legislation work towards the promotion of appropriate antibiotic behavior, other cognitive constructs influence behavioral displays. Alternatively, this behavior could have been influenced by culture. The only study [26] to explore the impact of ethnicity on public AMR behavior found vast differences between sub-groups within communities, where immigrant antibiotic attitudes greatly differed to community natives and were representative of the aforementioned division between developed and developing countries. Moreover, differences in public behavior were found within countries dependent on whether an individual resides in an urban or rural area. Those residing in rural communities more likely to have lower AMR knowledge [35, 36, 41, 51] and inappropriate antibiotic usage [35, 36] compared with their counterparts in urban areas. However, the factors that determine rural or urban living are left open to interpretation.

Knowledge, misconceptions and fallacies

All the studies identified [7, 8, 11, 20-59] referenced AMR or antibiotic knowledge, where high AMR knowledge is deemed as a predictor for appropriate antibiotic behavior [27, 52, 56]. Cumulatively, low AMR knowledge and misconceptions are interpreted to account for inappropriate public beliefs, expectations, and behaviors [25, 45]. However, AMR knowledge does not always predict positive antibiotic beliefs or behaviors. The public can have antibiotic fallacies while having high knowledge of AMR as a concept [27, 30, 45, 51, 56], holding the misconception that antibiotic stewardship does not affect AMR. Alternatively, some individuals have cognitive dissonance, where they have high knowledge of AMR and antibiotic stewardship yet hold disproportionate personal risk, believing they are personally not at risk from AMR or that they can contribute towards limiting AMR [21, 46]. When considered in terms of the health belief model [60], the adoption of appropriate AMR behavior is unlikely if perceptions of low risk are held supporting the identification of beliefs as a cognitive construct that influences public behavior compliance.

Within over 60% of the literature identified [7, 8, 20, 23, 25, 26, 28-30, 32, 37, 38, 41, 44-53, 55-57] the authors identified nine incorrect public beliefs towards antibiotics (see Table 1). When cumulatively interpreted, the fallacies demonstrate a lack of public knowledge on bacterial infections and how they are treated and evidence of antibiotic placebo beliefs,

Table 1: Antibiotic fallacies held by the public

Antibiotic Misconceptions and Fallacies	**Study identified**
Can treat viruses (e.g. Colds, flu, sore throats, earache)	7, 23, 29, 30, 32, 37, 38, 45-47, 49-53, 56, 57
Speeds up recovery	28, 29, 37, 38, 41
Prevents infection	29, 53
Prevents complications	26, 37, 48
Risks associated with use	37, 47
When to use	41
Expectations to receive irrespective of HCP diagnosis	8, 44, 55
Cure all mentality	20, 25, 45
Confused with other medication	50

where antibiotics are considered as effective prevention and cure-all drugs. Furthermore, disproportionate high-risk assessment towards treating viruses are also impacting public antibiotic behavior. In turn, these beliefs influence cognition as the public fails to assimilate appropriate antibiotic use and positive AMR behavior, resulting in inappropriate antibiotic demand, behavior compliance and increase risk of AMR infections [6, 7, 44, 55, 60].

Public Attitudes and the Social Influence of Friends and Family

The final theme identified addresses the expression of beliefs through attitudes and a shared social influence on the reinforcement of public AMR behavior. Over 20% of the studies reviewed [11, 20, 28, 29, 43, 44, 45, 53, 55] explored public attitudes towards the inappropriate use of antibiotics to self-medicate. Several common fallacies influencing attitudes towards self-medication were identified: it costs less, speeds up recovery, prevents complications and limits exposure to the social stigma associated with attending an HCP consultation for infection [20, 28, 53, 55]. While the influence of beliefs on cognition was found to influence attitudes towards antibiotic use [21, 27, 30, 45, 46 52, 56], self-medication fallacies suggest associable disproportionate risk assessment and a social influence of friends and family on public behavior [20]. Disproportionate risk was found in over a quarter of the studies reviewed [11, 20, 23, 28, 29, 33, 34, 43,

[44, 46, 53, 55], where the authors found that irrespective of high AMR knowledge, individual non-compliant antibiotic behavior reinforced by previous experience, availability to purchase, or social norms [61]. As well documented in other health-related change domains [62], irrespective of individual beliefs or knowledge, behavior can be socially determined and reinforced by perceptions of social norms. Social norms are unspoken behavior models that influence an individual to adopt or suppress certain behaviors if they are perceived to be socially acceptable through adoption of a shared risk assessment. As outlined by Rosenstock, Strecher and Becker [60] health-related behavior is influenced by individual cognitive perception of risk. Subsequently, social appropriation of misbeliefs could be argued are propagated by the personal networks as well as the family [20, 23, 28, 31, 33, 44, 47].

Eight of the studies reviewed [20, 23, 28, 31, 33, 34, 44, 47] identified community-based behavior that reinforces individual health-related behavior via a shared risk assessment. Various strategies that influenced individual cognition included: culturally shared fallacies [20], approximation of peer beliefs [23], social brokering of antibiotics by peer groups and family members that include HCPs [20, 28, 31, 44, 47], a lack of shared decision making during HCP consultations [34], and provision of prescriptions when not medically justified, as HCPs overestimate patient demand that is not representative of patient expectations [33]. Moreover, an individual can reciprocate influence upon social norms, as their previous experience with antibiotics can influence the behavior of their peer networks. Alhomoud et al. [20], identified that in a community where antibiotics are perceived as curative to all ailments, any instances where a person appears to be cured upon their use, even when they are medically unjustified, further promotes communal misuse and disproportionate risk assessments. Subsequently, this experience provides an inappropriate socially accepted model of AMR behavior [63], which could impact on community resilience to AMR. Then it could be reasoned that these factors inform social norms pertaining to AMR, influencing cognition constructs to inform behavior compliance and the attribution of personal risk [64].

Discussion

This scoping review sought to elucidate the cognitive constructs which influence public AMR behavior and the attribution of personal risk. Following the Arksey and O'Malley framework [18], forty-three studies were selected for review based on the research questions and three themes were identified: sociodemographic influences; knowledge, misconceptions, and fallacies; and, public attitudes and the social influence of friends and family. Analysis

of the literature identified knowledge [7, 8, 11, 29-59], beliefs [7, 8, 44, 55, 56], attitudes [11, 20, 28, 29, 43, 44, 45, 53, 55] and social norms [20, 23, 28, 31, 33, 34, 44, 47] as cognitive constructs which influence public AMR behavior compliance. The results of this research support the findings of previous studies [10, 11, 15, 16, 17] that suggest various cognitive constructs contribute towards informing public AMR behavior.

All the literature identified [7, 8, 11, 29-59] work to the premise that levels of AMR knowledge influence AMR behavior compliance; where high levels of knowledge can predict appropriate antibiotic behavior. However, the authors found that levels of AMR knowledge are influenced by sociodemographic categorizations [26, 35, 36, 40, 43, 49, 51, 56, 58]. The amount of AMR knowledge a person holds can be predicted by the level of education they have achieved [35, 36, 40, 49, 51, 56, 58], and the antibiotic behavior they display [49, 58]. As exposure to AMR interventions is not restricted to specific individuals within a community, it would be plausible to suggest that current interventional design restricts accessibility. As found by other studies [10], assumptions towards public homogeneity typically inform AMR education design; where the language used, or information provided is reliant on existing knowledge that some members of the public do not have. As outlined by Carlile's [65] framework for the transference, translation, and transformation of information, it is imperative that the abilities and expertise of the public are considered to ensure successful transmission of AMR education. Any deviation in the interpretation of the intended syntax, semantics or pragmatic application of the information transferred can distort the intended message negatively impacting public cognition. Cabral et al. [22] evidence this as they found members of the public associated AMR interventions with attempts to reduce healthcare organization expenditure by rationing antibiotics, failing to recognize personal risk.

Geographical location between and within countries was found to influence public cognition pertaining to AMR. Disparities between developed and developing countries were identified as the result of country wealth [43]; where people from less wealthy countries displayed less judicial antibiotic behavior [28, 53, 54]. People from low-middle income countries such as Turkey and India [66] have alternative healthcare infrastructure and legislation that indirectly promote non-judicial antibiotic use due to availability to purchase. Therefore, the use of AMR strategies that utilize a cohesive multi-disciplinary approach to AMR management that promotes and enforces AMR behavior compliance is supported. However, would reliance on the term 'developed healthcare infrastructure' to elucidate the differences reported between the global community sufficiently identify the components or strategies employed, which impact on public AMR behavior or do other factors contribute. Lindenmeyer et al. [26], found that immigrant communities within

developed countries held inappropriate AMR beliefs suggesting a possible influence of culture on AMR behavior compliance. Likewise, Lv et al. [46], found that irrespective of higher country wealth and AMR knowledge non-judicial usage was prevalent. Nevertheless, a further divide in AMR knowledge was found as a result of the dichotomy between rural or urban living by two studies [35, 36]; where those who reside in rural communities had less AMR knowledge than those who live in urban areas. However, the factors which determine the influence of rural or urban living on AMR are open to interpretation. Could rural living facilitate antibiotic self-medication, stockpiling and brokering within communities due to the distance they would need to travel to consult with an HCP, or could they represent other influences such as community, ethnicity or religion. Therefore, as used successfully in other health-related behavior domains [67, 68], use of community-specific, coproduced longitudinal pragmatic interventions is recommended. This type of educational design would work towards ensuring that AMR information is transferred and received in the manner intended, where the need to alter or maintain AMR behavior compliance is sufficiently stressed to inform cognition and increase community responsibility.

During this review, it became clear that within all the literature identified a dependent concept of AMR knowledge and antibiotic attitudes exist [7, 8, 11, 29-59]. However, this association was not always present for the public, as high AMR knowledge was not indicative of AMR behavior compliance [30, 45, 52, 56], suggesting a failure during information transference [65] that limits personal risk attribution. Numerous public misconceptions and fallacies were identified in nearly two-thirds of the literature reviewed [7, 8, 11, 20, 23, 25, 26, 28-30, 32, 37, 38, 41, 44-53, 55-57] that posits antibiotic misuse as beneficial to an individual, as they hold no responsibility towards AMR [16]. In turn, these public misconceptions and fallacies become the knowledge basis for individual cognitive risk assessment. As outlined by Rosenstock, Strecher and Becker [60], health-related behavior is assessed based on individual risk to the instigation or maintenance of behavior. Within the current literature, the authors found evidence of cognitive dissonance that highlights a disproportionate risk assessment towards the personal implications of AMR behavior compliance and restricts behavior change [8, 11, 44, 55, 59]. In order to inform an appropriate risk assessment, provision of pragmatic information that details how to effectively use antibiotics may work to dispel various antibiotic placebo fallacies; the use of pragmatic information has proven successful at managing health-related behavior change in various health domains such as diabetes [67]. Nevertheless, in line with the health belief model [60], the authors cannot exclude an effect of social influence on AMR knowledge, beliefs, behavior and attribution of personal risk.

The impact of social influence on AMR behavior compliance was explored by 20% of the studies reviewed [20, 23, 28, 31, 33, 34, 44, 47]. These papers identified community-based strategies that reinforce disproportionate individual risk assessment and provide a reference for socially acceptable behavior. Based on past experience and fallacies towards AMR, information on antibiotic use and behavior is brokered by peer networks, thus informing social norms of behavior. Social norms [69], are unwritten behavior models that guide cognition towards performing socially perceived appropriate behaviors. Compliance with social norms ensures social acceptance and appropriation of socially identified low-risk behavior. Additionally, compliance is seen as behavioral reinforcement, which further informs the basis of the behavior as a social norm to others. In terms of AMR, the act of antibiotic brokering between friends and relatives, including HCPs, is perceived as beneficial, where fallacies on antibiotics use are reinforced, supporting the social disproportionate risk identified in over a quarter of the studies reviewed [7, 20, 23, 28, 29, 33, 34, 43, 44, 47, 53, 55]. In order to address the impact of social norms, provision of AMR education should consider adopting similar strategies to those used in other domains, where campaigns go beyond a single intervention [64] to inform re-evaluation of risk. A shift in social norms for smoking [62], seatbelt use and drink driving [68] were achieved using the provision of repetitive longitudinal campaigns that provide accurate transference of information to dissipate fallacies and misconceptions while providing socially acceptable behavior models and guidance on how an individual can achieve behavior change. Moreover, as HCPs can be viewed as reliable sources of accurate health information by the public, they are afforded an influential status on information appropriation. Therefore, HCP education and training needs to be reviewed globally to ensure it sufficiently overcomes fallacies and misconceptions towards supporting judicial antibiotic use and the promotion of community resilience to AMR.

Limitations

While every attempt was made to ensure a credible and reflexive examination of current literature in this review, the findings of this scoping review are based on a collective review by the authors. No attempt was made to assess the scientific validity of the studies selected or statistically analyze the data. Moreover, limitations on the findings are influenced by the search terms used to identify literature, which may have unintentionally excluded key research. While the literature identified informed the findings of this research, a lack of literature on sociodemographic characteristics and educational design may influence the results reported. Therefore, conclusions based on the global differences between developed and developing countries is insufficient to inform directed impact on the factors which

influence AMR behavior compliance. Additionally, the influence of rural living, education level and ethnicity on AMR knowledge may reside in the small samples reported. It is possible that these differences are due to inappropriate information transfer [65] that fails to address gaps in existing knowledge permitting information transformation by the public. Albeit, while collectively all the studies recommend AMR education, a lack of specificity towards informing future design permits interpretation to the suggestion. Moreover, it could be argued that current literature places too much onus on the provision of AMR knowledge to impact pubic AMR behavior [7, 8, 11, 29-59], where this is not always the case [30, 45, 52, 56]. Therefore, going forward the authors recommend equal precedence is afforded to the cognitive constructs that influence AMR behavior, where heterogeneous interventional strategies are applied. Furthermore, no literature pertaining to the impact of research using longitudinal, participatory or coproduction were identified. Subsequently, this review seeks to stimulate debate on public AMR involvement and co-production, towards fostering public responsibility, knowledge, and self-efficacy. Consequently, this will work towards the normalization of appropriate behavior to limit AMR; with integration and assimilation of cognitive constructs that are evidenced as influencing public AMR behavior to inform future interventions, policy, and management.

Conclusion

The authors used the Arksey and O'Malley framework [18], to perform a credible and reflexive examination of literature, and identify the research questions: what cognitive constructs influence public AMR behavior, do these constructs contribute to the attribution of personal risk and behavior compliance and are there other factors that influence individual behavior constructs vis-à-vis AMR. Knowledge, beliefs, attitudes and social norms were identified as cognitive constructs that influence the attribution of personal risk and AMR behavior compliance. Other factors that influence cognition were identified as geographical location, education level, cognitive dissonance, and social dynamics. Numerous public misconceptions, fallacies and brokering of social norms contribute to disproportionate cognitive risk assessments and a lack of social responsibility towards AMR that is limiting global resilience. Literature towards the impact of sociodemographics is currently lacking, future research may benefit from the adoption of longitudinal, participatory designs to further elucidate the influences reported here. Likewise, research needs to establish an effect of information brokering on public AMR education, as syntax is reliant on assumptions of existing public knowledge. If left unaddressed by interventional design, misconceptions and fallacies that inform public perceptions of personal AMR responsibility and behavior are conceivable. Furthermore, as identified by the authors, the impact of social factors may afford an opportunity to inform interventional design that uses social

dynamics the dispel the publicly held placebo effect of antibiotics. Nevertheless, the influence of cognitive constructs on public AMR behavior and the attribution of personal responsibility are recognized, the authors recommend that future interventional design should address this influence to encourage the normalization of positive AMR behavior to limit individual, communal and global resilience.

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Appendix A summary of the literature included in the scoping review

Authors	Country	Antibiotic/ AMR Aim	Study Population	n =	Method	Key findings	Influences identified	Themes Identified
Pan et al. [7]	Singapore	Assessment of knowledge, attitudes, and practices towards antibiotics used for RTI, and explore associations between antibiotic expectations	patients seeking consultation when presenting URTI	987	Quantitative	Over third expected antibiotics from Drs, most would request them. If expectations were not met some would consult a different Dr.s A high percentage knew antibiotics did not work on viruses. However, judicial use was not observed by approximately 10%	expectations, fallacies, cognition into behavior	2. Knowledge, misconceptions and fallacies
Szenborn, Maciąga, Dul, Bortnowska & Jasonek [8]	Poland	Verification of knowledge and behavior of parents	Parents	634	Quantitative - questionnaire	A third indicated that they did not know the indicators for antibiotic use. While trust was high in Dr.s nearly a third used the internet to verify a doctor's diagnosis.	knowledge, misuse, fallacies, cognition into behavior self-medication	2. Knowledge, misconceptions and fallacies
Abujheisha, Al-Shdefat, Ahmed & Fouda [11]	Saudi Arabia	Explore public knowledge and attitudes	Public	670	Quantitative - questionnaires assessing knowledge and attitudes	69.9% aware of AMR, but 33.5% did not complete their courses. Over 56% indicated that they had stored unrequired antibiotics for future use. AMR education is required to address behavior change	Knowledge, attitudes, behaviour. Self-medication. Disproportionate risk	2. Knowledge, misconceptions and fallacies 3. Public Attitudes and Social Influence
Alhomoud, Aljamea & Basalelah [20]	Saudi Arabia	Explore the factors which influence antibiotic self-medication	Public- that admitted to antibiotic self-medication	40	Qualitative interviews	Common practices -1. cultural perspective is that antibiotics have curative power. 2. stored medication for future use or to share. 3. behavior reinforcement of improper use associated with health improvements. 4. Influenced their relatives and friends with this misconception. 5. Doctors do not communicate or share decision making. 6. Lack of access to care. 7. Lack of AMR knowledge. 8. Readiness and availability of antibiotics to purchase (lack of regulation), supports behavior reinforcement. 9. The stigma associated with having attended a consultation for infection can be socially undesirable	Social reinforcement, misconceptions, fallacies, misuse, knowledge, self-medication. Disproportionate risk	2. Knowledge, misconceptions and fallacies 3. Public Attitudes and Social Influence
Ancillotti et al. [21]	Sweden	Identifying factors that promote/ hinder judicious antibiotic use	Public	23	Qualitative - focus group	Contradicting egoistic and altruistic reasons were suggested as the basis for current AMR- required individual effort and overprescribing. Participants compared AMR to climate change and overestimated the likelihood of being affected by it.	The framing of AMR, misuse. High AMR knowledge, but not AMS	2. Knowledge, misconceptions and fallacies

Cabral et al. [22]	UK	To understand patients/ clinicians' perceptions of communication during consultations for their child's respiratory issues	Parents	27 parents	Qualitative thematic analysis of patient interviews	Parents understood the need to reduce antibiotic prescribing without understanding AMR. Some patients believed that reductions were designed to ration antibiotic usage. Clinician communication reinforces patient beliefs on the need for antibiotics	Knowledge, AMR, misconceptions	2. Knowledge, misconceptions and fallacies
Hawking et al. [23]	UK	To understand the attitudes and behaviors of adolescents towards AMR, antibiotics and respiratory infections	Teens aged 16-18	74 (53 in focus groups and 21 in interviews)	Qualitative-focus groups and interviews	Antibiotics are likened to over the counter pain killers. Believed that peers see them as a cure-all pill and they had no interest in antibiotics as a discussion topic. Low knowledge of viral and bacterial infections, antibiotics should be used to treat server infections such as tonsillitis. Previous experience has reinforced the use of antibiotics for RTI. AMR is seen as irrelevant, and a product of the body, not bacteria.	Knowledge, beliefs, attitudes, and fallacies. Social reinforcement. Disproportionate risk	2. Knowledge, misconceptions and fallacies 3. Public Attitudes and Social Influence
Heid, Knobloch, Schulz & Safdar [24]	USA	To identify themes associated with patient perception of antibiotic usage and the patient role in antibiotic stewardship	Inpatients that had received ineffective treatment	30	Qualitative interviews	Patients recognize AMR as an issue but do not feel they are personally at risk through AMR. Trust in HCPs and misconceptions on the mechanisms of AMR influenced views of susceptibility. Patients want more involvement in their care and expressed high self-efficacy. Patients believe their role to limit AMR is within asking questions speaking up and being more involved in their care/ decision making. Few said they were afforded this	lack of ownership, patients want to be involved, hospitalized patients	2. Knowledge, misconceptions and fallacies
Joseph et al. [25]	Pakistan	To understand the beliefs and behaviors that contribute to AMR in the context of treatment for adult diarrheal disease	Public and HCP	85 (40 lay & 45HCP)	Qualitative interviews	Over 50% of laypersons and 66% of HCPS are aware that antibiotics can lose effectiveness. Misconceptions were common with participants suggesting that the body becomes immune or that the bacterial starts to attack more strongly if medications are taken incorrectly. They also believe AMR is limited to a single effect; HCP behavior was rarely mentioned. Less than 50% of HCPS were aware of correct treatment procedures. With reference to prevention, few mentioned taking antibiotics only when required through prescription.	lack of knowledge, miscomprehension, fallacies, lack of professional understanding/ compliance with procedures	2. Knowledge, misconceptions and fallacies
Lindenmeyer et al. [26]	UK	Obtain recent migrant views on antibiotic use in primary care	Public	23	Qualitative interviews	Illness is perceived as infectious implying antibiotics are required to quickly prevent complications and spread of disease to others. People are used to antibiotics and the use of other medications as a substitute will be less effective to treat disease. Receiving a prescription is perceived as being a sign of taken seriously- a lack of prescription was contributing to ongoing illness.	Ethnicity. Social reinforcement, perceptions, misconceptions and fallacies	1. Sociodemographic influences. 2. Knowledge, misconceptions and fallacies

Van Hecke, Butler, Wang & Tonkin-Crine [27]	UK	Explore parents' beliefs, understanding of AMR in relation to RTI and strategies they consider acceptable to minimize AMR for their families	Parents	23	Qualitative - semi-structured interviews	Parents believed that their families were at low risk of AMR as they were low users. Few considered AMR as possible harm from antibiotics. Parents believed they were morally responsible by following antibiotic campaign advice. They suggest that future campaigns need to be relatable with accessible messages about AMR	Perceptions of risk, beliefs, high AMR knowledge but negative AMR behavior	2. Knowledge, misconceptions and fallacies
Widayati, Suryawati, Crespigny & Hiller [28]	Indonesia	Assess beliefs about self-medication purchasing	Public with experience of self-medication	25	Qualitative - interviews	Self-medication was cheaper, faster and reduced the need to use multiple drugs- contrasting judicial use. This was facilitated by availability, experience and social support (family, friends Inc. those with HCP backgrounds). Disadvantages of this behavior were identified to be poor health and AMR	Misconceptions, beliefs, fallacies and social reinforcement. High AMR knowledge does not translate into AMS behaviour. Disproportionate risk.	2. Knowledge, misconceptions and fallacies 3. Public Attitudes and Social Influence
Alzoubi, et al. [29]	Jordan	Assess public knowledge, beliefs and attitudes	Hospital outpatient pharmacy referrals	x2 hospitals 1091	Quantitative - multivariate analysis	80% though antibiotics can be used to treat colds/ flu. 40% believed that antibiotics cannot be used to prevent infection. 22 %willing to self-medicate if they thought it would benefit them	knowledge, attitudes, beliefs, fallacies, and demographics. Self-medication. Disproportionate risk	2. Knowledge, misconceptions and fallacies 3. Public Attitudes and Social Influence
André, Vernby, Berg & Lundborg [30]	Sweden	Measure knowledge of AMR and antibiotic use	Public	747	Quantitative - telephone questionnaire	19% believe antibiotics can cure colds/flu. 80% agreed to the prospect of AMR. Trust in doctors was higher when no antibiotics are used compared to when they are prescribed.	Knowledge, AMR, misconceptions and fallacies	2. Knowledge, misconceptions and fallacies
Barber et al. [31]	Philippines	To identify community-level - correlates between sociodemographic, knowledge and attitudes and antibiotic sharing	A community	307 questionnaires & 106 roadside stalls	Quantitative - logistic regression - questionnaires	78% of participants had shared antibiotics. Sharing was associated with other non-judicial antibiotic beliefs. 60% of stalls had antibiotics available to purchase without prescription (Amoxicillin was the most prevalent)	Antibiotic reinforcement, misconceptions, misuse, knowledge, social reinforcement	2. Knowledge, misconceptions and fallacies 3. Public Attitudes and Social Influence
Cals et al. [32]	Netherlands	To gain insight into public knowledge, beliefs, and experiences of antibiotics and RTI	Public aged 16+	935	Quantitative-questionnaire	45% of participants believed antibiotics can treat viruses. When terms such as acute bronchitis are used people's expectations for antibiotics increase	Knowledge, fallacies, beliefs	2. Knowledge, misconceptions and fallacies
Cho, Hong, & Park, [33]	South Korea	Explore knowledge/ beliefs of Drs, pharmacists, and parents	HC/Ps and parents	409 Drs, 158 pharmacists	Quantitative - questionnaire	92% of Drs believe that patients expect medication after a consultation. 73% of Drs reported feeling pressure (perceived expectations) to prescribe from patients. 15% of parents expect some form of medication after visiting the Drs for their child's cold. only 6% expected antibiotics. Moreover, only 19% of parents asked for medication but only 2% of patients reported asking for antibiotic prescriptions. 50% of patients believe doctors issue prescriptions rather than discussing the illness with them/81 % of Drs agreed with this. Only 39% of patients asked what was being prescribed to them.	Dr's reinforcement, misconceptions, misuse, knowledge. Social reinforcement. Disproportionate risk	2. Knowledge, misconceptions and fallacies 3. Public Attitudes and Social Influence

Coxeter, Del Mar & Hoffmann [34]	Australia	Quantify parents' expectations of antibiotic benefits, experiences of other options, exposure to and preferences for shared decision making and their belief on antibiotic usage.	Parents	401	Quantitative survey	Parents overestimate the benefits of antibiotics while 78% recognized they can cause harm. Shared decision making was inconsistent, only 44% reports some discussion with 75% wanting more involvement. 78 % reported not having a discussion on possible harm of antibiotics. 61% were not asked if they wanted antibiotics and 61% were not informed that they could choose to have them or not. while 50% knew Amr caused harm, the majority were confused as to what it was and how it forms.	Social reinforcement, misconceptions, misuse, knowledge. Disproportionate risk	2. Knowledge, misconceptions and fallacies 3. Public Attitudes and Social Influence
Cummings, Rosenberg & Vugia [35]	USA	To map the level of antibiotic misconceptions over 3 years	Women	7430 over two surveys	Quantitative-information taken from a state-wide health survey	Declines in misconception were related to education level, income, and ethnicity.	knowledge, education level, income	1. Sociodemographic Influences 2. Knowledge, misconceptions and fallacies
Drozd, Drozd, Filip & Bys [36]	Poland	To assess knowledge and beliefs	Public	609	Quantitative	The study showed a divide between rural and urban populations. Rural populations have less knowledge - do not know the terms antibiotics or herbal medicine, using them less frequently they do not know what they do. In total, over 75% perceive antibiotics as a last solution after home treatments fail. Young people were more likely to misuse antibiotics, citing a lack of time to be ill.	Geographical area of residence. Misconceptions, misuse, knowledge	1. Sociodemographic Influences 2. Knowledge, misconceptions and fallacies
Eng et al. [37]	USA	To explore knowledge, attitudes and behavior	Public	12,755	Quantitative-questionnaire/ survey	48% expected an antibiotic prescription when they had a cold. 27% believe antibiotics improved recovery from colds and 32% though they prevented complications. 48% of patients did not know the risk of taking antibiotics	Knowledge, misconceptions, fallacies. No sig diff for education levels	2. Knowledge, misconceptions and fallacies
Fredericks et al. [38]	Australia	To explore consumer attitudes and knowledge and to identify factors that contribute to antibiotic misuse	Public - pharmacy users	252	Quantitative - questionnaire	Incorrect responses showed that over 33% believed taking antibiotics would speed up recovery from a cold and over 20% believed that they could cure a cold/flu. Those with inaccurate beliefs were more likely to self-diagnose, which influences expectations of antibiotic prescriptions. 33% were unsure if AMR infections were difficult to treat with antibiotics. 29% were unsure if antibiotics could cure viral infections.	Shows reinforcement, misconceptions, misuse, knowledge and fallacies	2. Knowledge, misconceptions and fallacies
Friedman, Lee, Kleinman & Finkelstein [39]	USA	To determine parental and daycare predictors of acute care and antibiotic seeking for children	Daycare workers and parents	211	Quantitative - survey	Participants had high knowledge of correct antibiotics usage- care practices did not influence antibiotic seeking behavior or antibiotic expectations	respiratory, parents, antibiotic seeking behavior, knowledge	2. Knowledge, misconceptions and fallacies
Giannitsioti et al. [40]	Greece	To identify factors that hinder patient antibiotic perceptions	Public	605	Quantitative-questionnaire	Knowledge of Amr was higher for women, and those with lower education levels had less knowledge. Patient accountability was identified as the main cause for antibiotic misuse, by the patients questioned	Education level. knowledge, antibiotic usage/ misuse	1. Sociodemographic Influences 2. Knowledge, misconceptions and fallacies

Godycki-Cwirko et al. [41]	Poland	Describe knowledge, attitudes, beliefs on the use of antibiotics for RTI and contrast urban and rural populations	Public	1210	Quantitative - questionnaire	No major differences in knowledge existed between the rural and urban populations- but rural participants were less likely to know when they needed antibiotics and were more likely to leave the decision to their Dr.s However, a higher percentage of rural participants believed that antibiotics could speed up recovery from a sore throat. Level of education, number of children, and the awareness of AMR can predict accurate AMR knowledge on antibiotic effectiveness. Only 26% were correct in identifying that antibiotics do not treat viral infections.	knowledge, fallacies, and self-efficacy	2. Knowledge, misconceptions and fallacies
Gould, MacKenzie & Shepherd [42]	UK	An audit of the testing procedure and antibiotic prescribing	Drs and patients	673- patients 49 Drs	Quantitative - survey	50% think AMR is an issue, only 4% believed this was due to overprescribing and over 50% did not know. Over 55% wanted more information on AMR and 74% wanted this in a leaflet. Disease/ symptom-specific knowledge varied	AMR attitudes, patients want more information	2. Knowledge, misconceptions and fallacies
Grigoryan et al. [43]	Europe	To study the impact of attitudes, knowledge, and behavior (predisposing factors) and enabling factors - country wealth and health systems on self-medication	Public	1101	Quantitative	Self-medication was related to illness, availability, and beliefs (can be used to treat minor illness). Richer countries and those with dispensation rates that matched prescriptions were associated with lower self-medication. Unable to account for individual-level determents.	Beliefs cause behavior. Geographical location- between countries. Social reinforcement. Disproportionate risk	1. Sociodemographic Influences 2. Knowledge, misconceptions and fallacies 3. Public Attitudes and social influence
Haltiwanger, Hayden, Weber, Evans & Possner [44]	USA	Evaluation of college student's antibiotic seeking behavior and related parent satisfaction	Students	129	Quantitative	55% expected an antibiotic prescription when they have respiratory complaints. Expectations were higher for those who believed they had a bacterial infection. 1/3 have shared or re-used previous prescriptions	Expectations, patient satisfaction, self-medication. Social influence. Disproportionate risk. Fallacies. Cognition into behavior	2. Knowledge, misconceptions and fallacies 3. Public Attitudes and Social Influence
Kim, Moon & Kim [45]	South Korea	Examine public knowledge and attitudes re. AMR and antibiotics	Public	1177	Quantitative survey	Over 70% were unaware that antibiotics were ineffective at treating colds/flu/coughs. Over 66% understood the concept of AMR but were unsure as to the conditions under which it occurs. Lower knowledge was associated with older people and those with lower education levels. No exposure to AMR campaign material was associated with poor AMR attitudes. Only 30% were aware that antibiotics were ineffective at treating colds/ flu.	Attitudes, knowledge, fallacies, and self-medication. Age. High AMR knowledge does not equate to AMS	2. Knowledge, misconceptions and fallacies 3. Public Attitudes and Social Influence
Lv et al. [46]	China	Evaluate the knowledge, attitudes, and behavior of university students on the use of antibiotics	Students	731	Quantitative questionnaires	Self-medication was high 59%, 30% of which were used to treat colds. Inappropriate use and storage of antibiotics were found. Yet, they had moderately accurate beliefs.	Knowledge, antibiotic usage/ misuse and fallacies. Disproportionate risk	2. Knowledge, misconceptions and fallacies 3. Public Attitudes and Social Influence

McNulty, Boyle, Nichols, Clappison & Davey [47]	UK	Assess public knowledge, beliefs and attitudes and their reported antibiotic usage	Public	7120	Quantitative - survey	40% did not know antibiotics did not work on colds. 43% did not know antibiotics kill the bacteria that naturally live in the body. Lower education levels were associated with less AMR knowledge. Those with better knowledge were more likely to finish a prescribed course. women with more knowledge were more likely to share antibiotics	knowledge, education, fallacies, and behavior. Social reinforcement	2. Knowledge, misconceptions and fallacies 3. Public Attitudes and Social Influence
Moes, Carrico & Hall [48]	USA	Evaluate knowledge, attitudes, and beliefs about antibiotic use to treat simple viral infections, and determine if education will improve knowledge and examine the impact on patient satisfaction	Students visiting a college health center	44	Quantitative	Pre-intervention - participants believed it was better to take an antibiotic than to risk not improving. post-education knowledge significantly increased. 98% were happy with their care irrespective of receiving/ not receiving an antibiotic prescription.	knowledge, patient satisfaction, quality of care, fallacies	2. Knowledge, misconceptions and fallacies
Napolitano, Izzo, Di Giuseppe & Angelillo [49]	Italy	Assess public knowledge, attitudes and behaviors regarding antibiotics	Parents	419	Quantitative	Less than 10% knew what AMR was and only 21% knew when to use an antibiotic. Levels of education were associated with more judicious behavior and knowledge.	knowledge, education levels, fallacies and behavior	1. Sociodemographic Influences 2. Knowledge, misconceptions and fallacies
Panagakou et al. [50]	Greece	To document and analyze parental beliefs on antibiotic usage for children with URTI's	Parents	5264	Quantitative - questionnaire	74% expect to receive antibiotics for URIs. 48% believe earache should be treated with antibiotics, but 70% confused antibiotics with other treatments. Parents rarely self-medicated their children with 88% believing unnecessary antibiotic use drives AMR	knowledge, expectations	2. Knowledge, misconceptions and fallacies
Pavydė et al. [51]	Lithuania	To assess public knowledge, beliefs, and behavior pertaining to antibiotic use and self-medication	Public	1005	Quantitative - questionnaire	60% had poor AMR knowledge- not understanding how/when antibiotics should be used. Those with lower education level and those in rural communities were significantly less knowledgeable	Knowledge, education levels, rural, self-medication	1. Sociodemographic Influences 2. Knowledge, misconceptions and fallacies
Prigitano, Romanò, Auxilia, Castaldi & Tortorano [52]	Italy	Survey to assess use, knowledge, and awareness of AMR	Public	666	Quantitative - questionnaire	94% aware of AMR and only took antibiotics when instructed by a doctor. Knowledge/confusion on the applicability of antibiotics was found- participants were unsure when they should be used and what they should treat.	knowledge, fallacies, judicial use. High AMR knowledge but no AMS	2. Knowledge, misconceptions and fallacies
Shehadeh et al. [53]	Jordan	To assess knowledge, behavior, and attitude towards antibiotic use	Public	1141	Quantitative - questionnaire	Inadequate knowledge of judicial antibiotic usage was found. Over 65% believe antibiotics are used to treat colds with 55% using them as prophylaxis against infection. With 49% self-medicating and "8% kept antibiotics for an emergency.	knowledge, misuse, fallacies, self-medication	2. Knowledge, misconceptions and fallacies 3. Public Attitudes and Social Influence

Vinker, Ron & Kitai [54]	Israel	Evaluate parental expectations and knowledge of the role antibiotics play in childhood URTI	Parents of children presenting with symptoms of URTI at a pediatric clinic.	122	Quantitative - survey	Greater expectations for antibiotics were associated with lower levels of education, older parental age, previous experience of antibiotics, past perceived complications and incorrect knowledge on URTI treatment. Lower expectations were associated with higher levels of education and young parental age.	expectations, education levels, age	2. Knowledge, misconceptions and fallacies
Wang et al. [55]	China	Explore the behavior of university students in relation to antibiotics	Students	11,192	Quantitative - survey	Over 50% of those who presented a self-limiting illness received an antibiotic prescription, of which 22% had asked for one. Infection prophylaxis was used by 23% of participants- of which over half kept a personal stock and two-thirds bought them without prescription from a pharmacy. Lower antibiotic knowledge was associated with the need to consult a physician, receive a prescription and self-medication	knowledge, judicial use, misuse, self-medication.Fallacies. Disproportionate risk. Cognition into behavior	2. Knowledge, misconceptions and fallacies 3. Public Attitudes and Social Influence
Waaseth et al. [56]	Norway	Assess knowledge of pharmacy customers and assess the degree to which their beliefs and sociodemographic factors are associated with knowledge	Pharmacy customers in urban areas	877	Quantitative - survey	High knowledge of AMR and antibiotics was reported. Over 90% recognize the impact of antibiotic misuse on AMR. Antibiotic use knowledge was low over 30% believe antibiotics can help treat colds	Knowledge, education levels, comprehension. Fallacies. High AMR knowledge does not mean AMS is used	1. Sociodemographic Influences 2. Knowledge, misconceptions and fallacies
Wilson, Crane, Barrett & Gonzales [57]	USA	Understand public beliefs and use for RTI	Public	386	Quantitative - survey	Terms such as viruses and antibiotics are unclear. Over half believed antibiotics benefit viral infections. Where knowledge on these terms was clear, antibiotic use was lower	Knowledge, misconception understanding, RTI	2. Knowledge, misconceptions and fallacies
You et al. [58]	Hong Kong	Examine public knowledge, attitudes, and behaviors regarding UTI	Public	1002	Quantitative - survey	Over 70% held basic knowledge, appropriate attitudes/ beliefs, and behavior. Knowledge was associated with education level and family income. 9% reported acquiring antibiotics without prescription, while males were more likely to misuse	Knowledge, education levels,	1. Sociodemographic Influences 2. Knowledge, misconceptions and fallacies
McNulty et al. 2013 [59]	UK	exploration of patient RTI management	Pharmacy patients	1784 (1767 surveys, 17 interviews)	Mixed methods survey and interviews	Patients visit HCP when they believed their symptoms became severe or prolonged. Of the 58% who identified as having an RTI only 19% sought primary treatment with half of these expecting an antibiotic prescription. Patient associated symptoms with severity and severity with the need for HCP help. Perception of antibiotic side effects did not influence expectations, all who asked for a prescription were given one- 25% of these patients did not complete the course prescribed.	lack of knowledge, understanding influences behavior and expectations	2. Knowledge, misconceptions and fallacies