A Scoping Review to Assess the Impact of Public Education Campaigns to Affect Behavior Change pertaining to AMR

Abstract

Background: Years of global antibiotic misuse has led to the progression of antimicrobial resistance (AMR), posing a direct threat to public health. To impact AMR and maintain antimicrobial viability, educational interventions towards fostering positive AMR behavior change have been employed with some success

Methods: This scoping review sought to identify research-supporting use of public educational AMR campaigns and their efficacy towards informing positive AMR behaviors to inform current debate. To enable credible and reflexive examination of a wide variety of literature, Arksey and O'Malley (2005) methodological framework was used.

Results: Three primary themes were identified (1) behavior change and theoretical underpinnings, (2) intervention paradigm, (3) educational engagement. From 94 abstracts identified, 31 papers were chosen for review. More attention is required to identify elements of intervention design that inform and sustain behavior change and the impact of how an intervention is delivered and targeted, is needed to limit assumptions of population homogeneity, which potentially limits intervention efficacy. Moreover, research on the impact of hospital-based inpatient interventions is needed.

Conclusion: The existing body of research fails to provide robust evidence to support sound evidential interventions supported by theoretical justifications. Furthermore, interventions to ensure long term sustained behavior change are unclear and not addressed.

Key Words: Antimicrobial, Antibiotic, Resistance, AMR, Behavior-change, Education

AMR within a wide range of infectious agents is a growing threat to global health. Recent global estimations predict AMR will cause 10 million deaths a year and cost healthcare of over $100 trillion by 2050. [1] AMR occurs naturally, however, inappropriate antimicrobial use by patients and healthcare professionals has exponentially increased this process limiting antimicrobial viability. Presently, The World Health Organization (WHO)[2] reports that there are instances where antimicrobials required to treat gonorrhea, urine infections and pneumonia have been found ineffective. Antimicrobial usage is influenced by the knowledge, attitudes, and behavior of healthcare professionals and the public.[3] Research found that public pressure to prescribe antibiotics

induces practitioners into providing non-medically justified medication to maintain patient satisfaction and positive doctor-patient relationships. [4-8]

Global efforts seek to improve AMR knowledge through promotion and reinforcement of positive antimicrobial behavior. Some success in this area has been found where the number of antimicrobials prescribed has reduced, [9] while others report no effect. [10] Assessment of public AMR knowledge found that despite the employment of numerous educational campaigns, discrepancies in knowledge exists between and within WHO member states.[11] A literature review of public AMR knowledge and beliefs conducted by McCullough et al.[1] postulate that public knowledge is low, as participants believe they play no role in AMR or its solution. It is argued therefore that AMR education is essential to manage misconceptions and increase public awareness of sound antibiotic usage. Huttner et al. [12] reviewed AMR intervention literature and concluded that while education seems to reduce outpatient antibiotic usage, the most prevalent method eluded them. More recently, a systematic review of public AMR campaigns [13] suggested that multi-faceted educational interventions are the most effective way of reducing antibiotic prescriptions, but they failed to identify a method of AMR behavior change sustainability.

Public engagement with educational material should not be assumed; [14] various factors will influence engagement; the mere provision of AMR education is insufficient towards fostering and sustaining behavior change. A longitudinal assessment of various French national AMR campaigns [15] reported that changes to prescribing practice correlated with the use of educational interventions; initially national prescribing rates fell and then plateaued. Moreover, within population disparity was observed; elderly prescribing rates quickly returned to pre-intervention levels. Many behavior change theories recognize cognition as a precursor for sustained behavior change. AMR interventions that neglect cognition, incur limited effects of longevity, sustainability or longitudinal impact on behavior. Prochaska and Velicer [16] would argue that the provision of health literature could have a counter-intuitive effect, which induces stress and anxiety that could negatively affect public AMR behavior.

The current review aims to provide an updated review of existing AMR educational interventions and the efficacy of such campaigns in altering and sustaining AMR behaviors, to progress research and identify methods to inform future AMR intervention, legislation and management.

METHODS

The use of scoping reviews to examine the breadth of literature pertaining to a chosen topic is becoming increasingly popular as a method of review. [17] This method of analysis was selected over more traditional systematic reviews, as a scoping review permits cumulative identification and evaluation of literature that employed various measures to identify existing gaps in literature to inform current debate and a future research study, on sustained AMR behavior change.

The Arksey and O'Malley [17] methodological framework was used to formulate this review. Use of this method allowed credible and reflexive examination of a wide variety of literature on public educational AMR interventions; while ensuring methodological rigor and transparency, enabling future replication and validation of the current findings.

Research Questions

1. What is the research supporting the use of public educational AMR campaigns?

2. What is the efficacy of these campaigns towards sustained behavior change?

Relevant Literature and Study selection

Figure 1 outlines and charts the processes used for this review towards identifying and screening the studies.

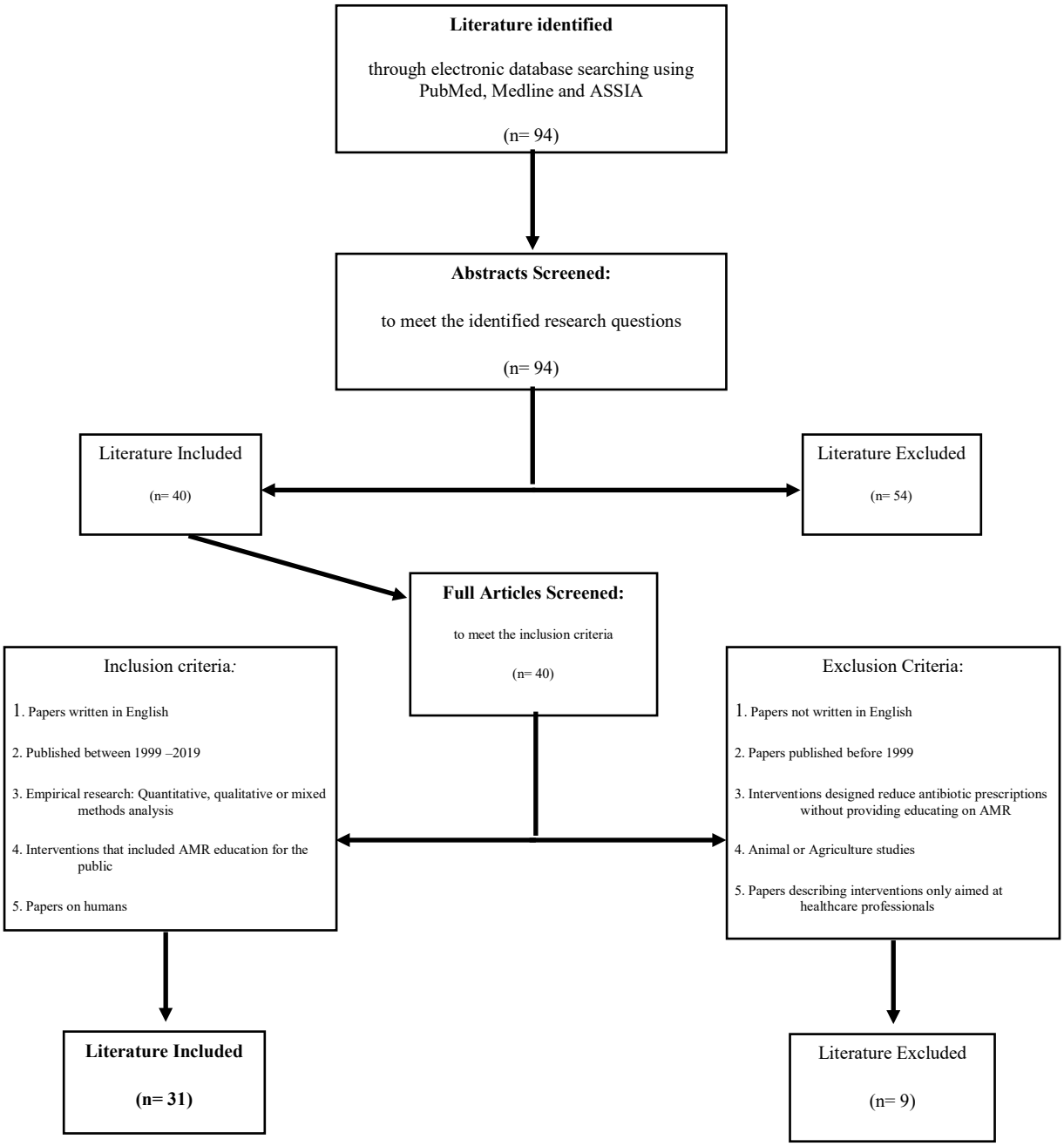

Figure1: Application of Arksey and O'Malley [17] methodological Framework for this review by the authors

Charting the data and summarizing

Table 1 summarizes and charts the literature included for review (See appendix A)

RESULTS

All thirty-one studies selected for review shared the premise that AMR education can foster positive behavior change. Efficacy was measured in three ways, cumulatively, via the number of antimicrobials prescribed (issued for prescription, defined daily doses, antibiotic sales or medical insurance claims), [3, 9, 15, 18-27], individual

assessment (beliefs, knowledge, adherence or behaviour), [28-40,] or a combination of both, [41-43] one study reported the percentage of AMR found in cultures. [24] While efficacy measures differ, two of the studies [41, 43] that measured the cumulative and individual impact of AMR education on behavior found that both measures are reflective of each other, supporting the use of either methodology to measure AMR behavior change. However, Formoso et al. [20] found a reduction in prescribing rates did not equate to improved public knowledge. Likewise, Hennessy et al. [24] found no correlation between reduced prescription rates and the number of AMR bacteria found in cultures. Further investigation to substantiate a correlation of AMR behavior measures is therefore warranted.

The studies identified further differed in terms of methodology. Eight studies [9-11, 15, 27, 34, 36, 44,] evaluated the effect of national AMR interventions. Another eight studies [19, 21, 22, 24, 33, 31, 37, 41] locally enhanced national campaign material. A further eight [3, 18, 20, 25, 26, 32, 36, 38] used unique educational material designed by the researchers. Four studies [28-31] evaluated the UK based Antibiotic Guardian (AG) campaign, while the design or source of the material used by two studies [23, 42] was unclear. While this varied approach limits evaluation and comparison of the material used to inform behavior change, the majority of the studies reported success in affecting AMR knowledge or behavior in some way, with three studies [3, 23, 41,] failing to identify any direct change.

Identified Themes

The literature included within this scoping review was primarily screened by all authors individually, then collectively, to reach a consensus on the themes identified: AMR behavior change and theoretical perspectives, interventional paradigm, and disease specificity.

AMR Behavior Change and Theoretical Perspectives

Eight of the studies identified [3, 18-20, 28-31] described a theoretical basis for the methods employed to alter public behavior, four of which specifically pertain to the AG campaign. [28-31] Two debated origins of behavior change propose that change occurs via the principles of behaviorism (social learning through repetition and reinforcement of displayed behavior), [44] or through ongoing cognitive appraisal. [16, 45-47] Use of behavior change theory in intervention design has been previously associated with sustained health-related behavior change in domains such as smoking cessation, eating disorders, HIV education and IPC practice. While numerous behavioral theories exist, individual cognitive appraisal required for sustained behavior change is recognized. [16, 44, 46, 47] Only one study identified [3] described using principles of behaviorism to influence positive AMR behavior change, as measured via changes to prescription rates; while change was noted, prescription rates fell for both the control

and intervention states, without significant difference. Alternatively, two studies [19, 20] described applying the principles of Social Marketing Theory in intervention design, [45] that outline the need to understand the causality of current behavior to successfully promote determents and encourage change. Both studies [19, 20] targeted healthcare professionals (HCP) and the public with varied media, successfully decreasing prescription rates. However, an increase in public AMR knowledge was not observed, [20] suggesting the design of the intervention employed was insufficient to sustain public AMR behavior change; results of this intervention could solely be attributed to the education of HCP. Unfortunately, due to the sustained influence of patient expectations on HCP prescribing, [4-8,] failing to impact public behavior may have a longitudinal effect on reversing HCP behavior change.

Half of the studies [28-31] that used a theoretical basis for behavior change all pertain to evaluation of the AG campaign, which is based on several theories that recognize the effect of cognitive appraisal on sustained behavior change. [16, 46, 47] The campaign aims to offer an opportunity for an individual to change behavior after increasing their capabilities and self-efficacy via AMR education, towards encouraging self-regulatory strategies that lead to formation or maintenance of sustained habitual behavior. The public, HCP, and educators are encouraged to make a behavior pledge to become an antibiotic guardian (AG); they abide by suggested behavioral actions that limit AMR and spread AMR awareness. While the evaluative studies [28-31] report that those who pledge have better AMR knowledge, the campaign appears limited to those with pre-existing AMR cognition, working to reinforce existing behavior. Therefore, as the campaign is insufficient to encourage initial cognitive appraisal it may be more beneficial as a tool to maintain behavior change initiated by an alternative intervention, as applied by Allison, Higginson, and Martin. [39] Alternatively, one study [18,] which followed the trans-theoretical theory [16,] to design their successful 5-year controlled community intervention. The theory [16,] outlines six stages of decision making towards intentional behavior change that an individual can revisit due to cognitive, affectional or evaluative processes they perform: pre-contemplation, contemplation, preparation, action, maintenance, and termination of previous unhealthy behaviors. Samore et al.[18] aimed to encourage cognition, and subsequent progression through the stages to sustain positive behavior change through the use of two different educational approaches. The first addressed AMR knowledge and the second delivered months later provided treatment guidelines that encouraged shared decision making with physicians. Moreover, a greater decrease in prescribing rates was found when the intervention was directed at both physicians and the public, suggesting HCP intervention involvement is more likely to influence public cognition and behavior change, supporting Gonzales et al. [21, 22] findings.

Interventional Paradigm

On review, two methods of intervention paradigm were identified. The first method employed a multifaceted approach that was successfully used or evaluated by most of the studies identified. [9-11, 15, 18-22, 24-31, 40, 42, 43] Use of this method permits the possibility of repeated interventional exposure from various media or HCP to the public. The second method adopted by six studies, [32-34, 36, 38, 39] used a single educational approach to encourage AMR behavior change. While the methods employed by these studies may exist within multifaceted campaigns, use of a single method to explore the impact of an intervention permits identification of elements that will successfully contribute to positive public behavior change, advising future interventional design (see table 2 for summary).

Paper	Nature/ style	Educational Method	Education provided by	Intervention Location	Behavior Measure	Outcome
Munoz et al. 2014 [32]	1 to 1	Verbal	Pharmacist	Pharmacy	Adherence	Adherence was higher for those who received an educational intervention
Shehadeh, Suaifan & Hammad, 2016 [33]	1 to 1	Verbal with written reference card	Pharmacist	Pharmacy	Knowledge	AMR knowledge increased after the intervention
Giannitsioti et al. 2016 [34]	Literature	Printed Informational leaflet	Nurse	Hospital Outpatients	Public opinion	Regional demographics influence knowledge
Micallef et al. 2017 [36]	Literature	Printed Informational leaflet	?	Hospital Outpatients	Knowledge	The public don't know what AMR is & Recall was high for illness specific information
Ngadimon et al. 2017 [38]	Group work	Verbal, printed literature & group activity	Pharmacist	High School	Attitudes & Knowledge	As knowledge increased so did the desire to participate/ have shared decision making
Allison, Higginson & Martin, 2017 [39]	Group work	Verbal, printed literature & group activity	Pharmacist	High School	Knowledge & Self-reported Intended Behavior	Providing AMR knowledge informed use of other behavioral strategies to limit AMR

Table 2: Summary of the Six Single Exposure Studies

As seen in table 2, the six studies [32-34, 36, 38, 39] that used singular exposure methods, all reported AMR behavior change efficacy. A re-occurring design feature is the use of an HCP or healthcare site when providing AMR education; suggesting that provision of education by or in a healthcare institution, works to foster successful AMR behavior change. It is possible that the provision of education via publicly perceived experts reinforces positive AMR behavior. Likewise, the use of professionals to provide information affords the public an opportunity to ask questions, which may positively influence their cognitive appraisal towards positive AMR behavior; that cannot be achieved through the use of a self-acquired leaflet.

Disease Specificity

From the studies identified over 90% of educational material focused on an umbrella term of AMR, with small reference to cold and flu treatment made in four studies. [3, 19, 25, 43] The remaining three studies [21-23] focused specifically on respiratory infections and how they relate to AMR. While behavioral change success has been found using an umbrella term of AMR, two studies [36, 37] report that public AMR knowledge and tangibility increases when AMR is given context using disease-specific information. Both studies conducted by Gonzales et al. [21-22] aimed at the public and HCP, found success in reducing respiratory infection prescribing rates. Although this seemed to only impact adult rates, the number of antibiotics prescribed for children remained unaffected.[21] Alternatively, Plachouras et al. [23] found prescription rates fell during the intervention, but they failed to be sustained. However, while the authors stated this reflected national usage, no control for seasonal trends was applied during data analysis.

DISCUSSION

On reflection, the literature identified shared the perception that lack of knowledge limits positive AMR behavior. Twenty-seven studies [9-11, 15, 18-22, 24-40, 43, 44] reported finding positive AMR behavior change after interventional use. Throughout the literature employed, interventional efficacy measures varied, with emphasis placed on either prescribing rates, individual assessment or both. While either measure could be used to assume AMR behavior change, it remains unclear as to the corroborative nature of these measures, due to conflicting findings between the studies that discussed both [20, 24, 41, 43,] further research is warranted to enable associative comparisons. Moreover, one study [24,] included biological measures of behavior change, finding that reduced prescription rates did not infer reduction of AMR bacteria found in the community. However, a lack of longitudinal analysis was found in the literature, which limits conclusions towards sustained intervention efficacy. Three studies [3, 18, 27,] assessed the varying impact of AMR education for 5 years or more, and one study [15] that evaluated ten years of educational campaigns, found that some of the population reverted to pre-intervention behavior after five years, suggesting current AMR education does not inform sustained behavior change and associated cognitions.

As successfully adopted in other health domains to sustain health-related behavior change, the use of behavior change theory to construct and evaluate interventions is advisable. Theoretical basis of intervention design was identified in seven of the studies [18-20, 28-31] that reported intervention efficacy; four provided evaluation of a national campaign, [28-31] two studies [19, 20] outlined the influence of theory on design, and one study [18,] outlined

the influence of theory on design and longitudinal analysis enable measurement of sustained behavior change. Samore et al. [18,] used educational content that was: varied, multifaceted, and sequential, ensuring it was matched to the stages of cognition while allowing longitudinal analysis. Use of this method permitted behavior relapse as identified by Prochaska and Velicer,[16] without impacting measurements of sustained behavior. Alternatively, Plachouras et al. [23] found that prescription rates reduced when their intervention was introduced but quickly returned to pre-intervention levels. It is possible that due to the short duration of this study, results only captured part of the temporal dimension of change. [16] Therefore, it could be argued that a theoretical behaviour change framework that informs AMR behaviour change requires a more sustained, multifaceted longitudinal approach to public education and individual behavior. Although, it would be naïve to assume that the use of behavior theory alone will enable sustained change. As witnessed in the identified literature, several studies [11, 15, 35] identified the effect of culture and demographics pertaining to AMR behavior change; societal norms, [48,] values, beliefs, folk laws and level of health literacy needs to be addressed during interventional design to ensure an intervention meets the needs of the intended audience and not assume public homogeneity.

Multifaceted campaigns are effective at attaining positive AMR behavior change, [6] but due to the inclusive nature of the design adopted, direct assessment of intervention components is not permitted. Two such studies, [21, 22] described finding increased behavior change when interventions were targeted at both HCP and the public, in contrast to interventions only targeting the public. As a proxy, successful single exposure interventions (see table 2) [32-34, 36, 38, 39] detail using HCP or a healthcare institution to provide an AMR intervention. Ho et al. [40] reported that multifaced campaigns create public awareness of AMR, use of HCP to provide AMR education had the largest impact on public cognition and behavior change. Therefore, while it is possible that these campaigns facilitated behavior change as they were culturally appropriate, Bandura and Walters [48] recognize the impact of social influence as a medial process of cognition and behavior. It could be argued that HCP involvement increases behavior change as it encourages obedience to the directions of an authority figure, [49] or an act of social conformity. [50] Moreover, HCP AMR education fosters personal relevance, ownership, and tangibility to the public, addressing current views that they have no role in AMR development or reduction. [1, 37]

Another method to encourage cognition and AMR behavior change was highlighted by two studies. [36,37] Micallef et al. [36] found public recall of disease-specific AMR education was significantly higher than AMR information. Use of disease-specific education encourages public engagement, as information pertaining to a specific infection such as E. coli is a more tangible risk to individual health. [37] This type of direct appeal has been

used previously by numerous behavior change campaigns, such as the successful British Think Seatbelts [51] campaign that used relatable instances to depict what can happen to the individual if behavior change was not adopted, initiating cognition and sustained behavior change. In terms of infection prevention and control, intervention, policy and practice guidelines for hand hygiene have led to reductions of multiple HCAI [52, 53] and AMR bacteria. Interventions such as the Geneva hand hygiene promotion model [53] outline the need to provide policy and practice guidelines with education tailored to the local community to foster cognition associated with behavior change; creating individual ownership, encouraging adjustment of collective behavior, reinforcing social learning and sustained behavior change, which would benefit AMR management.

LIMITATIONS

As with all scoping reviews, this research is limited based on collective review. While empirical research was sought, no attempt to assess the scientific validity of the varying analyses or evaluation of statistical power calculations were made to inform review inclusion; in some instances, the literature reviewed failed to identify the number of participants used. Moreover, no subsequent statistical analyses on the collective study results were performed in the completion of this review thus limiting the robustness and validity of the paper, which future research needs to address This review is further limited by the terms used to search research databases and applicability to the research questions identified; it is possible that using alternative words would have identified additional literature. Likewise, the parameters applied to the searches made to limit research (between 1999 – 2019, humans, English language papers) may have inadvertently excluded earlier research, international research or those which failed to identify the use of human participants. Therefore, it could be argued that use of a systematic review methodology would be more appropriate. However, this review offers insight into the efficacy of public AMR educational campaigns and the methods used to design and deliver the interventions advising future research and design.

Future research needs to address the limitation of the interventional approaches identified in the current literature: inconsistent use of efficacy measures, lack of theoretical underpinnings to inform design and analysis, and the assumptions of public homogeneity and engagement. Adoption of a holistic approach to AMR education, where locally tailored interventions mirror national campaigns that are composed and regulated by professionals from multiple disciplines is imperative. Ideally, a set of accepted transferable metrics could be used in order to provide a platform for interventional comparison and assessment. It is argued that this move draws parallels from successful behavior change campaigns in other domains [51-53,] that influenced legislation, policy, and practice

respectively, to reinforce and sustain behavior change. Moreover, this move could work towards addressing the non-existent literature outlining the use of patient AMR education in acute hospitals to align patient beliefs with prescribing practice, as seen in primary care. [19] Use of this method would also work towards improving the quality of care and encourage shared decision-making.

CONCLUSION

This scoping review used the Arksey and O'Malley[17] methodological framework for the credible and reflexive examination of a breadth of literature and identify two research questions. The first question sought to identify the research supporting the use of public educational AMR campaigns and the second sought to identify the efficacy of these campaigns towards sustaining behavior change. On reflection, public knowledge increases following AMR education encouraging cognition and behavior change to impact AMR. However, the existing body of research fails to provide robust evidence to support sound evidential interventions that are supported by theoretical justifications. Furthermore, interventions to ensure long term sustained behavior change are unclear and not addressed. Adoption of methods employed in other health domains can inform future design and offer proven methods towards attaining sustained behavior change. Moreover, no research identified elucidated interventional use within secondary care settings, forgoing an opportunity to target and educate those at higher risk of AMR infections. This paper adds to the current debate as it focuses on public behavior pertaining to AMR; it questions and highlights the need to refocus AMR educational interventions towards the public using a more holistic approach with an emphasis on theory.

Financial Disclosure

No funding was received to conduct this research.

References

1. McCullough, A. R., Parekh, S., Rathbone, J., Del Mar, C. B., & Hoffmann, T. C. (2015). A systematic review of the public's knowledge and beliefs about antibiotic resistance. *Journal of Antimicrobial Chemotherapy*, *71*(1), 27-33. doi:10.1093/jac/dkv310
2. World Health Organization. (2018). Antimicrobial Resistance: The Key Facts. Available from: https://www.who.int/en/news-room/fact-sheets/detail/antimicrobial-resistance. Accessed February 5, 2019
3. Belongia, E. A., Knobloch, M. J., Kieke Jr, B. A., Davis, J. P., Janette, C., & Besser, R. E. (2005). Impact of statewide program to promote appropriate antimicrobial drug use. *Emerging infectious diseases*, *11*(6), 912. doi: 10.3201/eid1106.050118
4. Cockburn, J., & Pit, S. (1997). Prescribing behaviour in clinical practice: patients' expectations and doctors' perceptions of patients' expectations—a questionnaire study. *BMJ*, *315*(7107), 520-523. doi: 10.1136/bmj.315.7107.520
5. Kumar, S., Little, P., & Britten, N. (2003). Why do general practitioners prescribe antibiotics for sore throat? Grounded theory interview study. *BMJ*, *326*(7381), 138. doi: 10.1136/bmj.326.7381.138
6. Pinder, R., Sallis, A., Berry, D., & Chadborn, T. (2015). Behaviour change and antibiotic prescribing in healthcare settings. Literature review and behavioural analysis. *Public Health England*. Available from: http://hdl.handle.net/10044/1/22194 Accessed February 5, 2019
7. Vinson, D. C., & Lutz, L. J. (1993). The effect of parental expectations on treatment of children with a cough: a report from ASPN. *Journal of Family Practice*, *37*(1), 23-28.
8. Wester, C. W., Durairaj, L., Evans, A. T., Schwartz, D. N., Husain, S., & Martinez, E. (2002). Antibiotic resistance: a survey of physician perceptions. *Archives of internal medicine*, *162*(19), 2210-2216. doi:10.1001/archinte.162.19.2210
9. Goossens, H., Guillemot, D., Ferech, M., Schlemmer, B., Costers, M., van Breda, M., ... & Davey, P. G. (2006). National campaigns to improve antibiotic use. *European journal of clinical pharmacology*, *62*(5), 373-379. doi.org/10.1093/jac/dkl188
10. McNulty, C. A., Nichols, T., Boyle, P. J., Woodhead, M., & Davey, P. (2010). The English antibiotic awareness campaigns: did they change the public's knowledge of and attitudes to antibiotic use?. *Journal of Antimicrobial Chemotherapy*, *65*(7), 1526-1533. doi.org/10.1093/jac/dkq126

11. World Health Organization. (2015). Antibiotic resistance: Multi-country public awareness survey. Available from: https://www.who.int/drugresistance/documents/baselinesurveynov2015/en/ Accessed February 4, 2019

12. Huttner, B., Goossens, H., Verheij, T., & Harbarth, S. (2010). Characteristics and outcomes of public campaigns aimed at improving the use of antibiotics in outpatients in high-income countries. *The Lancet infectious diseases*, *10*(1), 17-31. doi: 10.1016/S1473-3099(09)70305-6

13. Cross, E. L. A., Tolfree, R., & Kipping, R. (2016). Systematic review of public-targeted communication interventions to improve antibiotic use. *Journal of Antimicrobial Chemotherapy*, *72*(4), 975-987. doi: 10.1093/jac/dkw520

14. Whitehead, D. (2001). Health education, behavioural change and social psychology: nursing's contribution to health promotion?. *Journal of Advanced Nursing*, *34*(6), 822-832. doi: 10.1046/j.1365-2648.2001.01813.x

15. Bernier, A., Delarocque-Astagneau, E., Ligier, C., Vibet, M. A., Guillemot, D., & Watier, L. (2014). Outpatient antibiotic use in France between 2000 and 2010: after the nationwide campaign, it is time to focus on the elderly. *Antimicrobial agents and chemotherapy*, *58*(1), 71-77. doi: 10.1128/AAC.01813-13

16. Prochaska, J. O., & Velicer, W. F. (1997). The transtheoretical model of health behavior change. *American journal of health promotion*, *12*(1), 38-48. doi: 10.4278/0890-1171-12.1.38

17. Arksey, H., & O'Malley, L. (2005). Scoping studies: towards a methodological framework. *International journal of social research methodology*, *8*(1), 19-32. doi: 10.1080/1364557032000119616

18. Samore, M. H., Bateman, K., Alder, S. C., Hannah, E., Donnelly, S., Stoddard, G. J., ... & Rupper, R. (2005). Clinical decision support and appropriateness of antimicrobial prescribing: a randomized trial. *Jama*, *294*(18), 2305-2314. doi: 10.1001/jama.294.18.2305

19. Finkelstein, J. A., Huang, S. S., Kleinman, K., Rifas-Shiman, S. L., Stille, C. J., Daniel, J., ... & Goldmann, D. (2008). Impact of a 16-community trial to promote judicious antibiotic use in Massachusetts. *Pediatrics*, *121*(1), e15-e23. doi: 10.1542/peds.2007-0819.

20. Formoso, G., Paltrinieri, B., Marata, A. M., Gagliotti, C., Pan, A., Moro, M. L., ... & Magrini, N. (2013). Feasibility and effectiveness of a low cost campaign on antibiotic prescribing in Italy: community level, controlled, non-randomised trial. *BMJ*, *347*, f5391. doi: 10.1136/bmj.f5391

21. Gonzales, R., Corbett, K. K., Leeman-Castillo, B. A., Glazner, J., Erbacher, K., Darr, C. A., ... & Kafadar, K. (2005). The "minimizing antibiotic resistance in Colorado" project: impact of patient education in improving antibiotic use in private office practices. *Health services research*, *40*(1), 101-116. doi: 10.1111/j.1475-6773.2005.00344.x

22. Gonzales, R., Steiner, J. F., Lum, A., & Barrett Jr, P. H. (1999). Decreasing antibiotic use in ambulatory practice: impact of a multidimensional intervention on the treatment of uncomplicated acute bronchitis in adults. Jama, 281(16), 1512-1519. doi:10.1001/jama.281.16.1512

23. Plachouras, D., Antoniadou, A., Giannitsioti, E., Galani, L., Katsarolis, I., Kavatha, D., ... & Sakka, V. (2014). Promoting prudent use of antibiotics: the experience from a multifaceted regional campaign in Greece. *BMC Public Health*, *14*(1), 866. doi: 10.1186/1471-2458-14-866

24. Hennessy, T. W., Petersen, K. M., Bruden, D., Parkinson, A. J., Hurlburt, D., Getty, M., ... & Butler, J. C. (2002). Changes in antibiotic-prescribing practices and carriage of penicillin-resistant Streptococcus pneumoniae: a controlled intervention trial in rural Alaska. *Clinical Infectious Diseases*, *34*(12), 1543-1550. doi: 10.1086/340534

25. Perz, J. F., Craig, A. S., Coffey, C. S., Jorgensen, D. M., Mitchel, E., Hall, S., ... & Griffin, M. R. (2002). Changes in antibiotic prescribing for children after a community-wide campaign. *Jama*, *287*(23), 3103-3109. doi:10.1001/jama.287.23.3103

26. Lambert, M. F., Masters, G. A., & Brent, S. L. (2007). Can mass media campaigns change antimicrobial prescribing? A regional evaluation study. *Journal of antimicrobial chemotherapy*, *59*(3), 537-543. doi: 10.1093/jac/dkl511

27. Sabuncu, E., David, J., Bernède-Bauduin, C., Pépin, S., Leroy, M., Boëlle, P. Y., ... & Guillemot, D. (2009). Significant reduction of antibiotic use in the community after a nationwide campaign in France, 2002–2007. *PLoS medicine*, *6*(6), e1000084. doi: 10.1371/journal.pmed.1000084

28. Bhattacharya, A., Hopkins, S., Sallis, A., Budd, E. L., & Ashiru-Oredope, D. (2016). A process evaluation of the UK-wide Antibiotic Guardian campaign: developing engagement on antimicrobial resistance. *Journal of Public Health*, *39*(2), e40-e47. doi: 10.1093/pubmed/fdw059

29. Chaintarli, K., Ingle, S. M., Bhattacharya, A., Ashiru-Oredope, D., Oliver, I., & Gobin, M. (2016). Impact of a United Kingdom-wide campaign to tackle antimicrobial resistance on self-reported knowledge and behaviour change. *BMC Public Health*, *16*(1), 393. doi: 10.1186/s12889-016-3057-2

30. Kesten, J. M., Bhattacharya, A., Ashiru-Oredope, D., Gobin, M., & Audrey, S. (2018). The Antibiotic Guardian campaign: a qualitative evaluation of an online pledge-based system focused on making better use of antibiotics. *BMC public health*, *18*(1), 5. doi: 10.1186/s12889-017-4552-9

31. Newitt, S., Anthierens, S., Coenen, S., Lo Fo Wong, D., Salvi, C., Puleston, R., & Ashiru-Oredope, D. (2018). Expansion of the 'Antibiotic Guardian'one health behavioural campaign across Europe to tackle antibiotic resistance: pilot phase and analysis of AMR knowledge. *The European Journal of Public Health*, *28*(3), 437-439. doi: 10.1093/eurpub/ckx239

32. Munoz, E. B., Dorado, M. F., Guerrero, J. E., & Martínez, F. M. (2014). The effect of an educational intervention to improve patient antibiotic adherence during dispensing in a community pharmacy. *Atencion Primaria*, *46*(7), 367-375. doi: 10.1016/j.aprim.2013.12.003

33. Shehadeh, M. B., Suaifan, G. A., & Hammad, E. A. (2016). Active educational intervention as a tool to improve safe and appropriate use of antibiotics. *Saudi Pharmaceutical Journal*, *24*(5), 611-615. doi: 10.1016/j.jsps.2015.03.025

34. Giannitsioti, E., Athanasia, S., Plachouras, D., Kanellaki, S., Bobota, F., Tzepetzi, G., & Giamarellou, H. (2016). Impact of patients' professional and educational status on perception of an antibiotic policy campaign: a pilot study at a university hospital. *Journal of global antimicrobial resistance*, *6*, 123-127. doi: 10.1016/j.jgar.2016.05.001

35. Huh, K., Chung, D. R., Kim, S. H., Cho, S. Y., Ha, Y. E., Kang, C. I., ... & Song, J. H. (2018). Factors affecting the public awareness and behavior on antibiotic use. *European Journal of Clinical Microbiology & Infectious Diseases*, 1-6. doi: 10.1007/s10096-018-3283-x

36. Micallef, C., Kildonaviciute, K., Castro-Sánchez, E., Scibor-Stepien, A., Santos, R., Aliyu, S. H., ... & Enoch, D. A. (2016). Patient and public understanding and knowledge of antimicrobial resistance and stewardship in a UK hospital: should public campaigns change focus?. *Journal of Antimicrobial Chemotherapy*, *72*(1), 311-314. doi: 10.1093/jac/dkw387

37. Wellcome Trust. (2015). Exploring the consumer perspective on antimicrobial resistance. Available from: https://wellcomelibrary.org/item/b24978000#?c=0&m=0&s=0&cv=0. Accessed January, 25 2019

38. Ngadimon, I. W., Islahudin, F., Shah, N. M., Hatah, E. M., & Makmor-Bakry, M. (2017). Improving shared decision-making in adolescents through antibiotic education. *International journal of clinical pharmacy*, *39*(1), 120-125. doi: 10.1007/s11096-016-0407-1

39. Allison, D. G., Higginson, P., & Martin, S. (2017). Antibiotic resistance awareness: a public engagement approach for all pharmacists. *International Journal of Pharmacy Practice*, *25*(1), 93-96. doi: 10.1111/ijpp.12287

40. Ho, M. L., Cowling, B. J., Seto, W. H., Wong, L. C., & Wong, T. Y. (2014). Determinants of an effective antibiotic campaign: Lessons from Hong Kong. *Journal of global antimicrobial resistance*, *2*(4), 334-337. doi: 10.1016/j.jgar.2014.08.001

41. Parsons, S., Morrow, S., & Underwood, M. (2004). Did local enhancement of a national campaign to reduce high antibiotic prescribing affect public attitudes and prescribing rates?. *The European journal of general practice*, *10*(1), 18-23. doi: 10.3109/13814780409094222

42. Arparsrithongsagul, S., Kulsomboon, V., & Zuckerman, I. H. (2015). Multidisciplinary perspective intervention with community involvement to decrease antibiotic sales in village groceries in Thailand. *Asia Pacific Journal of Public Health*, *27*(2), NP2480-NP2488.L. doi: 10.1177/1010539513479968

43. Hemo, B., Shamir-Shtein, N. H., Silverman, B. G., Tsamir, J., Heymann, A. D., Tsehori, S., & Friedman, N. L. (2009). Can a nationwide media campaign affect antibiotic use?. *The American journal of managed care*, *15*(8), 529-534. Available from: https://www.ajmc.com/journals/issue/2009/2009-08-vol15-n8 Accessed January 28, 2019

44. Manikam, S., & Russell-Bennett, R. (2016). The social marketing theory-based (SMT) approach for designing interventions. *Journal of Social Marketing*, *6*(1), 18-40. doi: 10.1108/JSOCM-10-2014-0078

45. Skinner, B. F. (1981). Selection by consequences. *Science*, *213*(4507), 501-504. Available from: https://pdfs.semanticscholar.org/7119/6a4ad8b25edfaedbb769192af87573a73bf5.pdf. Accessed March 10, 2019

46. Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, *50*(2), 179-211. doi: 10.1016/0749-5978(91)90020-T

47. Michie, S., Van Stralen, M. M., & West, R. (2011). The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implementation Science*, *6*(1), 42. doi: 10.1186/1748-5908-6-42

48. Bandura, A., & Walters, R. H. (1977). *Social learning theory* (Vol. 1). Englewood Cliffs, NJ: Prentice-hall.

49. Milgram, S. (1963). Behavioral study of obedience. *The Journal of abnormal and social psychology*, *67*(4), 371. doi: 10.1037/h0040525

50. Bond, R., & Smith, P. B. (1996). Culture and conformity: A meta-analysis of studies using Asch's (1952b, 1956) line judgment task. *Psychological Bulletin*, *119*(1), 111. Available from: http://www.academia.edu/download/50032617/SmithBondConformity.pdf. Accessed March 15, 2019

51. Department of Transport. (2019). *Think Seatbelts Julie campaign.* Available from https://www.think.gov.uk/about-think/story-of-think/ Accessed March, 8 2019

52. Stewardson, A., & Pittet, D. (2012). Anatomy of a successful multimodal hand hygiene campaign. doi: 10.1136/bmjqs-2012-001452

53. Pittet, D., Hugonnet, S., Harbarth, S., Mourouga, P., Sauvan, V., Touveneau, S., & Perneger, T. V. (2000). Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. *The Lancet*, *356*(9238), 1307-1312. doi: 10.1016/S0140-6736(00)02814-2

Appendix A

Table 1: Summaries for all identified Literature

Authors	Country	Duration	Behavior Measure	Study Population	n =	Aim	Method	Intervention	Key findings
Belongia et al. 2005 [3]	USA	1999 - 2004	Prescribing rates	H/Cs and public	N/a (State wide data)	To reduce/ improve antibiotic usage & AMR knowledge	Regional controlled staged intervention over 5 years	Theoretical underpinnings - Public intervention- printed information, mass media advertisements, educational presentations in childcare centres. Physicians- education included mailings, susceptibility reports, practice guidelines, satellite conferences, and presentations.	Prescribing rates reduced. Regional differences in reductions were noted.
Goossens et al. 2006 [9]	Belgium & France	N/a	Prescribing rates	H/Cs & public	2600	To assess the impact of public education	Evaluation of national usage	Evaluation of multiple national campaigns using mass media	ddd- significantly reduced after AMR education
McNulty, Nichols, Woodhead & Davey, 2010 [10]	UK	winters of 2008 & 2009	Knowledge	Public	3718	Public AMR Engagement	National controlled pre and post AMR knowledge assessment	Evaluation of a national campaign- printed material	Recollection of the campaigns increased. Antibiotic use did not improve. Knowledge did not improve.
WHO 2015 [13]	global	N/a	Knowledge	Public	9722	To identify public awareness and establish associations with demographics	Global knowledge assessment	Evaluation of Global AMR education	Discrepancies in knowledge exist between member states and within countries: between rural and urban communities- rural had less knowledge Older people and those in poor countries have less AMR knowledge.
Bernier et al. 2014 [15]	France	10 years	Prescribing rates	Public	N/a (national data)	Assessment of French national campaigns	Prescription rates during campaign months (cold months oct-march) and warm months (April - Sept) was compared over the duration of 10 years	Evaluation of national campaigns delivered over 10 years	National campaigns may not appeal to every demographic, discrepancies in knowledge are associated with age.
Samore et al. 2005 [18]	USA	5 yrs.	Prescribing rates	H/Cs & public	18 Communities	To measure the value of an H/Cs & Public intervention compared to just a public intervention vs. controls	Regional cluster randomized trial, adjust for seasonal changes in prescribing	Theoretical underpinnings - was designed to encourage communication with H/Cs and inform/sustain behavior change. Full intervention - H/Cs received a decision support system; printed material and PDA. Limited intervention Public only - targeted printed media - the first phase addressed AMR knowledge. 2nd phase provided knowledge on illness treatment and management assistance with Patient education.	Results showed that intervention groups achieved lower prescriptions- H/c & patient interventions combined achieved lower prescriptions-compared to controls

Finkelstein et al. 2008 [19]	USA	Oct - March 2000-2003	Prescribing rates	H/Cs & public	N/a	To determine the impact of a multifaceted, community-wide intervention on overall antibiotic use for young children	Regional controlled, community-level, cluster-randomized trial in 16 communities	Theoretical underpinnings- Social marketing principles applied to encourage engagement via appeal - provided to parents of young children. messages were consistent with the CDC campaigns but adapted to meet local need	Prescribing was lower for controls once patient expectations were aligned with prescribing practice
Formoso et al. 2013 [20]	Italy	3 months	Prescribing rates	H/Cs and public	4.3 million	To test the hypothesis that a multifaceted local public campaign could be feasible and influence antibiotic prescribing	Regional, controlled assessment of prescribing, public knowledge & attitudes pre & post intervention	Theoretical underpinnings- Social marketing principles applied to encourage engagement. Local tailoring of campaign material with printed materials, media, and newsletter for H/Cs	Impacted prescription rates but public knowledge was unaffected. Results may be due to H/C education alone
Gonzales et al. 2005 [21]	USA	2 yrs.	Prescribing rates	Public	5 Practices, 427 controls	To establish an effect of a patient education program on antibiotic prescribing for acute respiratory infections.	Regional non randomized controlled study (x2 control groups local and distant) receiving verbal AMR instruction	CDC and previously utilized AMR information were provided via printed material and mass media advertising of just HC verbal directed efforts.	Patient education helps reduce antibiotic prescription rates for adults when compared with the control group. No effect was found on children rates
Gonzales, Steiner, Lum & Barrett Jr, 1999 [22]	USA	November-February 1996-97, 1997-98	Prescribing rates	H/Cs & public	2110	To decrease antibiotic usage for bronchitis in adults	Regional nonrandomized, controlled trial of a multidimensional intervention	Full intervention - H/Cs received education, practice-profiling, and academic detailing. And the public received printed material. the limited intervention group received only the public intervention targeting homes and offices with printed material	Prescriptions only reduced for those who received the full intervention
Plachouras et al. 2014 [23]	Greece	3 months	Prescribing rates	H/Cs & public	1065	To educate the public and doctors, on AMR and decrease antibiotic consumption.	Regional assessment of public behavior prior to educational intervention, measures of prescription rates after	Academic detailing for H/Cs. Educational presentations for the public and printed material	No effect on behavior
Hennessy et al. 2002 [24]	USA	1998 - 2000	Prescribing rates & Percentage of cultures found	H/Cs & public	3326	Alter prescribing practices and carriage of Streptococcus pneumoniae	Regional staged, controlled non-randomized trial to assess the impact on prescribing rates and number of AMR cultures found	The intervention was based on messages from the CDC and tailored to locals. Educational seminars, newsletters, printed materials and stalls at community fairs	Prescriptions decreased per area as the intervention was extended

Perz et al. 2002 [25]	USA	May 1997 - April 1998	Prescribing rates	H/Cs & public	N/a (400 200 participant years)	Assess the efficacy at reducing inappropriate prescriptions for children	Regional controlled non randomized intervention assessment	Educational material developed by the CDC. H/Cs received lectures, presentations new guidelines. The public received printed material containing the messages: antibiotics only for bacterial infections, colds and coughs are viruses	Reduced antibiotic 19% reduction for intervention 8% for controls
Lambert, Masters & Brent, 2007 [26]	UK	January-February 2004 & 2005	Prescription rates	Public	N/a (Regional data)	Reduce inappropriate antibiotic prescribing via education	Regional controlled intervention comparison of pre & post intervention rates	Regional specific campaign and printed material. Local media adverts using campaign cartoon mascots	Reduced antibiotic prescribing by 5.8%
Sabuncu et al. 2009 [27]	France	7 yrs.	Prescribing rates	H/Cs & public	N/a (453 million cases)	Longitudinal assessment of national campaigns	Within comparisons - before after education - no. prescriptions during winter months only.- controlled for seasonal variance	Evaluation of national Campaigns over 7 years. Written material, mass media, training of daycare workers to deliver an educational message of AMR	A marked reduction of unnecessary antibiotic consumption- especially for children.
Kesten, Bhattacharya, Ashiru-Oredope, Gobin & Audrey, 2018 [30]	UK	N/a	Public opinion	H/Cs and public	22	To change behavior on AMR and increase knowledge via pledges.	National qualitative analysis - to capture views and experience of the campaign - why people pledged	See Bhattacharya, Hopkins, Sallis, Budd & Ashiru-Oredope, 2016 [23]	AMR concern motivated pledging. Pledge was forgettable but most believed they had met it. Campaign visibility was restricted to those with previous AMR knowledge- found to reinforcement current behavior. AGs believed collective pledge action was more beneficial in compared with individuals' action
Newitt et al. 2018 [31]	Europe	6 months	Knowledge	H/Cs & public	367	Assess engagement/knowledge	No. pledges from translated AG campaign website and knowledge AG knowledge vs. non-AGs	Bhattacharya, Hopkins, Sallis, Budd & Ashiru-Oredope, 2016 [23]	AMR knowledge is higher for AGs compared to non-AGs. Visibility is limited to those with pre-existing knowledge; the campaign has limited public reach.
Munoz et al. 2014 [32]	Spain	8 months	Adherence	Public	126	Assess the effectiveness of education on antibiotic adherence and patient reported resolution of symptoms	Regional controlled non randomized trial	Local pharmacist-delivered personalized AMR education based on an assessment	Adherence was higher for those who received an educational intervention
Shehadeh, Suaifan & Hammad, 2016 [33]	Jordan	4 months	Knowledge	Public	271	Knowledge	Regional randomized selection- before and after education	Using an info card designed by the CDC, pharmacists provided education on AMR for those collecting antibiotic prescriptions	AMR knowledge increased after the intervention

Giannitsioti et al. 2016 [34]	Greece	15 days	Public opinion	Public	605	To identify patient beliefs and assess knowledge	Regional odds ratio analysis- linking demographics to knowledge/ beliefs	A leaflet based on EAAD themes was given to hospital outpatients	Regional demographics influence knowledge. 81% had previously heard of AMR
Huh et al. 2018 [35]	South Korea	5yrs	Knowledge & demographic odds	Public	3000	Assess public awareness on Amr and identify the association between knowledge and demographics	National randomized telephone number dialling -interviews	Evaluation of two national campaigns that included printed material, television and radio advertising, and public education seminars	Better knowledge associated with better Amr behavior. Poor behavior, attitudes, and knowledge associated with a geographical location. Knowledge is associated with the level of education, media exposure, occupation
Micallef et al. 2017 [36]	UK	1 day	Knowledge	Public	1450	To assess knowledge	Regional, hospital-based assessment of patient knowledge after receiving an educational intervention	Patients at a hospital outpatient clinic received a printed educational leaflet on EAAD	The public did not know what AMR is. The recall was high for illness specific information
Wellcome Trust, 2015 [37]	UK	N/a	Public opinion	Public	N/a	To understand the public perspective on AMR	Regional qualitative analysis - to capture views and experience of AMR campaigns	General evaluation of AMR knowledge	AMR only has meaning when it is related to a specific disease i.e. E.coli, only then does it become relevant to the public
Ngadimon et al. 2017 [38]	Malaysia	6 months	Attitudes & Knowledge	Public	510	To identify the effect antibiotic education has on a willingness to engage in shared decision-making among adolescents	National assessment of teen AMR knowledge before and after education and SDM practice	Educational material was designed based on the national campaign	As knowledge increased so did the desire to participate/ have shared decision making
Allison, Higginson & Martin, 2017 [39]	UK	N/a	Knowledge & Self-reported Intended Behaviour	Public	N/a	To improve public engagement via education of school children	Regional questionnaire to identify teen knowledge; provided education and encourage AG membership	Design based on previous research- sought to utilize a varied approach to sustain behavior change, with students directed to the AG campaign website. In class, material was designed to involve student engagement- printed material and games	Providing AMR knowledge informed use of other behavior strategies to limit AMR
Ho et al. 2014 [40]	Hong Kong	7 months	Knowledge, attitudes & behavior	Public	1527	Assess the impact of two national campaigns	National randomized participant selection - before and after population comparisons.	Mass media used to convey AMR education. H/Cs received lectures and attended publicized AMR dinners to make positive AMR behavior pledges	Info received from H/C profs had the biggest impact
Parsons, Morrow & Underwood, 2004 [41]	UK	August 1999 - February 2000	Prescription rates & attitudes	H/Cs & public	1257	Assess the local impact of enhancing a national campaign, and assess the impact on prescribing	Regional assessment of a national campaign. Randomized selection between the difference	Regional campaign enhanced of a national campaign with increased use of printed material	No effect on behavior replicating the national campaign

Arparsrith-ongsagul, Kulsomboon & Zuckerman, 2015 [42]	Thailand	N/a	Antibiotics available for sale & Knowledge	Public	40 Villages	To reduce the number of antibiotics available for illegal purchase without prescription- limit Amr	Regional control before and after. No. antibiotics available to purchase. Knowledge levels before & after	The campaign was developed using information acquired through focus meetings. local grocers were trained to educate the public on AMR	Availability of antibiotics to purchase reduced
Hemo et al. 2009 [43]	Israel	November - February 2005 & 2006	Prescribing Rates and attitudes	Public	2 million	Evaluation of the effectiveness of a national campaign to reduce antibiotic prescriptions and public attitudes	Regional comparison of antibiotic usage before and after the campaign - assessment of parent attitudes and campaign exposure	Mass media campaign on AMR linked with messages to advise Flu treatment	Reduced antibacterial prescribing. parents exposed to the campaign more likely to agree with positive behavior towards AMR