

PUBLIC HEALTH | RESEARCH ARTICLE

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Media use and antimicrobial resistance misinformation and misuse: Survey evidence of information channels and fatalism in augmenting a global health threat

Jacob Groshek¹, James E. Katz¹, Brittany Andersen^{1*}, Chelsea Cutino¹ and Qiankun Zhong¹

Abstract: Recent research has identified that antimicrobial resistance (AMR) is giving rise to a global public health threat that involves all major microbial pathogens and antimicrobial drugs, and additional studies have found that despite its gravity, this threat is not reflected in public opinion of AMR. This study thus proceeds to examine which individuals among the general public are more likely to be misinformed about AMR and report misusing AMR-related products. Specifically, traditional media (newspaper, radio, television) consumption and social media use are modeled as factors which may not only reinforce but perpetuate AMR misinformation and misuse. Based on these findings, this study outlines a multidimensional framework of recommended practices for science communicators working in the contemporary media environment to minimize AMR misinformation and misuse.

Subjects: Pharmacology; Internet & Multimedia - Computing & IT; World Wide Web; Databases; Health and Social Care; Health & Society; Health Conditions; Infectious Diseases; Public Health Policy and Practice

Keywords: antimicrobial resistance; traditional media; social media; science communication; antibiotics; fatalism

ABOUT THE AUTHORS

The authors of the study are faculty and graduate student researchers from Boston University College of Communication's Division of Emerging Media Studies. The Division's research revolves around the relationships between media, technology, and users. As a whole, the group analyzes social networks, media, and virtual and augmented realities. Specific attention is paid to the social and cultural implications of an increasingly connected world. The research in this study further examines cultural implications of how online communication, specifically messages regarding antimicrobial resistance, may not only reinforce but perpetuate antibiotic misinformation and misuse.



Jacob Groshek

PUBLIC INTEREST STATEMENT

Antimicrobial resistance (AMR) refers to the ability of a microorganism, such as a virus or bacteria, to withstand an antibiotic treatment. As a result of AMR, standard antibiotic treatments are no longer effective, and the infection could worsen or spread to others. AMR is giving rise to a global public health threat that involves all major microbial pathogens and antimicrobial drugs. Despite its gravity, this threat is not reflected in public opinion of AMR. This study thus proceeds to examine which individuals among the general public are more likely to be misinformed about AMR and report misusing AMR-related products. Specifically, traditional media (newspaper, radio, television) consumption and social media use are modeled as factors which may not only reinforce but perpetuate AMR misinformation and misuse. Based on these findings, this study outlines recommended practices for science communicators working in the contemporary media environment to minimize AMR misinformation and misuse.

1. Introduction

The excessive use of antibiotics has markedly increased antimicrobial resistance (AMR) among community-acquired bacterial infections (Goossens et al., 2006), which suggests that drug resistance presents an ever-increasing global public health threat that involves all major microbial pathogens and antimicrobial drugs (Levy & Marshall, 2004). Importantly, however, this risk has not been well understood by the general public from countries around the world (McCullough, Parekh, Rathbone, Del Mar, & Hoffmann, 2016), even though the prevalence of antimicrobial drug use has been shown to be as high as 96.2% among acute care inpatients (Magill et al., 2014) in the United States. Over the same time period that AMR has been increasing, there has been a well-documented rise in the use of, and reliance on social networking sites (SNS) for news to the extent that Pew Research Center (2015) reported that social media platforms are now primary sources of information for multiple age cohorts in the American population. This study therefore examines media, and social media in particular, as sources of AMR misinformation that may contribute to members of the general US public not only misunderstanding the threat of AMR but also the misuse of AMR-related products such as antibiotics.

While previous research has found external factors that influence AMR awareness include economy, culture, public policies, and medical systems (Avorn & Solomon, 2000; Harbarth, Albrich, & Brun-Buisson, 2002), few studies have directly examined social media consumption and uses for how they shape AMR knowledge and behavior, though it has been shown that awareness of public health is not generated only by media exposure, but also from personal experience and conversation (Gray & Ropeik, 2002).

Altogether, the field of AMR awareness and behavior therefore remains in need of further study, particularly as it relates to incorporating a vastly altered and rapidly shifting media environment from a top-down hierarchical traditional media model to a decentralized, user-producer orientation on social media. The goal of this study is to provide a communications perspective on an issue typically examined under a scientific, medical lens. As Smith, M'ikanatha, and Read's (2015) call to action emphasizes, communications research is needed to understand how to change deep-set public attitudes and behaviors regarding AMR. In specifically answering this call, we thus proceeded to investigate social media uses as these intersect with other socio-demographic characteristics to better explain AMR misinformation and misuse in the US. Specifically, this study utilizes theories of information exchange and the spread of rumors to understand how misinformation might grow in online social environments.

2. A review of media and misinformation literature

A theoretical explanation of the spread of information in social networks contends that as social agents interact, information should converge towards an underlying truth (Acemoglu, Ozdaglar, & ParandehGheibi, 2010). Under this framework, there are two types of agents that exist in a social network, regular and forceful. In a perfect world, all individuals would be regular agents who "update their beliefs to be equal to the average of their pre-meeting beliefs" after communicating with others (Acemoglu et al., 2010, p. 195). Forceful agents, though, are those who impose their beliefs more strongly and are less willing to accept the beliefs of others. As a result, forceful agents direct social understanding and imbue discussions with bias.

According to earlier work on the subject, forceful agents may correspond to "media outlets" that actively aim to influence public opinion, or "community leaders" who might have greater influence over citizens' beliefs (Acemoglu et al., 2010, p. 195). In other words, forceful agents are those who emerge as dominant voices in a dispute over the contestation of facts. In this way, both traditional mass media (i.e. broadcast television, radio, print) and particularly vocal agents that may emerge on new media (such as social media, blogs, or other platforms of user-generated content) have the potential to skew the public's understanding of an unclear issue.

Following from this general framework, this study likens the spread of misinformation about antibiotics to the spread of rumors in a social network. Rumors arise because of humans' inherent need to make sense of the world, and can occur wherever people interact, whether those interactions take place in real life or virtual environments (DiFonzo, 2008). Specifically, rumoring can be defined as "a collective and collaborative transaction in which community members offer, evaluate, and interpret information to reach a common understanding of uncertain situations...and to solve collective crisis problems" (Oh, Agrawal, & Rao, 2013, p. 409). Thus, rumors are most likely to surface and spread in situations of uncertainty where information is left unverified (Garrett, 2011). Like rumors, the use of antibiotics is a topic engendered by uncertainty seeing as much of the population has a poor understanding of the issue and their own role in the problem (McCullough et al., 2016).

2.1. Cultivating misinformation online

Previous research has shown that most individuals generally process rumors online in much the same way as they would offline (Bordia & Rosnow, 1998), but some have suggested that features of the online environment might accelerate the spread of misinformation (Garrett, 2011; Katz, 1998; Luckerson, 2014). Fundamentally, the internet offers a simple, inexpensive, and highly accessible means of communication for much of the population. As a result, this develops an "environment in which any claim can find expression, from carefully vetted news to rumors and lies" (Garrett, 2011, p. 256).

Especially as internet use becomes more prevalent and mobile, the amount of information and array of varying ideological outlets has proliferated to the point of "information overload" (Garrett, 2011). Consequently, this vast amount conflicting evidence and opinions makes it difficult for the modern media consumer to discern what is truly accurate. Sharing information within online social circles can also create a vicious cycle of self-reinforcement. Garrett (2011) explains: "The more rumors someone encounters, the more likely he or she is to share them with others; and the more rumors that people share, the more opportunities that others have to encounter the rumors" (p. 260).

As compared to traditional mass media outlets, the internet invites user input, therefore reducing the role of gatekeepers in the dissemination of information (Garrett, 2011; Katz, 1998). On SNS such as Facebook and Twitter, users have the opportunity to share information whether it is sourced from a venerable news site or simply a (perhaps wrongly informed) personal friend. In informal social environments such as this, the main implication is that information spread via the internet may be less subject to fact-checking and verification than traditional journalistic sources or institutions. As rumor theory would predict, a lack of verification heightens the possibility that misinterpreted information will spread across online social networks (Garrett, 2011).

The extent to which rumors are embraced online may also be a function of the type of online communication users engage in. In a study on the spread of rumors through online sources (e.g. news, blogs) versus through email, Garrett (2011) found that email was a particularly dangerous space in which political rumors were spread and more readily accepted by participants. There are several psychological mechanisms at play to help explain the power of email in spreading rumors. For one, people are more likely to believe information originating from someone they personally know, and therefore, trust. In turn, this both reduces the probability that internet users will fact-check their acquaintance's information as well as increases the likelihood that the user will go on to share that information with others (Garrett, 2011).

Social networks such as one's email contacts also carry the added bias in that they are more likely to consist of like-minded individuals, which might cut out conflicting viewpoints and perspectives. This is coupled with the well-established psychological phenomenon, confirmation bias, whereby people are more likely to agree with information that supports their pre-existing beliefs. And ultimately, this psychological positioning means they are also less likely to fact-check such information (Garrett, 2011).

Drawing from this body of work, social media sites might function in a similar way to email and therefore exacerbate the problem of online rumor-mongering (Garrett, 2011). Like email, social networking sites like Facebook and Twitter “foster informal communication across network ties, especially among homogeneous groups of family members and close friends” (Garrett, 2011, p. 270). Social network platforms might even be more potent than email in terms of their reach and speed of information exchange. On top of this, misleading information from social networks like Twitter often pools into search engine results which may also feed into viral misunderstandings.

For example, an analysis of real-time search results on Google for a political election revealed that the engine produced “disproportionate exposure to...unverified events, lies and misinterpretations” (Metaxas & Mustafaraj, 2010). More recently, Oh et al. (2013) also studied how rumors spread over Twitter in the wake of crisis situations such as shootings and attacks. While they were unable to find a connection between social ties and the spread of rumors in this context, they linked personal involvement and source ambiguity to rumor mongering. Additionally, a 2011 study (Qazvinian, Rosengren, Radev, & Mei, 2011) found that a large proportion of people purposefully spread rumors on social media, fully aware that the claims were false. Given these findings the role of social media in the spread of misinformation as well as potential underlying mechanisms of this phenomenon are clearly in need of further examination and explication.

Importantly, evidence suggests that individuals are relying more and more upon social media platforms for news (Oh et al., 2013; Pew Research Center, 2015). In fact, most Americans now use Twitter (63%) and/or Facebook (63%) as a source of news, and this finding emerges in nearly all demographic groups (Pew Research Center, 2015). Similar to the argument that people are more likely to trust information from people they know (Garrett, 2011), people may be turning away from news outlets that tend to sensationalize news and instead towards social networks with local, more personally-relevant information (Oh et al., 2013) where there appears to be a level of trust in locally-sourced news, at least when it comes to crisis situations.

Should the same pattern persist for health news involving antimicrobial resistance, this finding would implicate how users consume news pertaining to AMR. Especially since social media information is subject to less fact-checking than journalistic sources, relying on social networks for news can well negatively impact how accurately its (more frequent) users understand the world. While much of the research on rumor-generation has focused on emergency situations and politics, it is equally necessary to examine how the spread of misinformation might occur in a more stable, health-related controversy, and whether a reliance on social media for news contributes to that sort of misinformation, which, as in the case of AMR, may pose a threat to global health.

Similarly, another problematic aspect of social media is that these sites allow greater opportunity for users to more formally generate opinions by making posts or sharing content. The problem here lies in that individuals tend to adhere more strongly to beliefs that are self-generated (Baumeister & Finkel, 2010) and when using social networking sites, evidence of one’s stance or leaning in an issue is more concrete when specifically explicated on a profile, message, or post. In a way, content has an indefinite shelf life online and is forever retrievable, even if deleted by the original user, for example, others may have archived that content through any number of techniques such as taking a screenshot or downloading entire threads. In addition, once committed to an idea or position, research has shown that individuals are less likely to change their beliefs once articulated and shared publicly (Sunstein, 2002). This self-reinforcement through using and performing on social media might well contribute to a vicious cycle in which misinformation that is initiated from uninformed citizens gets shared, others share as well, and then users have more difficulty changing their opinions when differing (correct) evidence arises.

The nature of AMR as a topic might also make it particularly difficult to combat misinformation. In this particular case, it could be counter-intuitive for some people to assume that in the face of more resistant bacteria, experts advise curbing the usage of antibiotics on the whole. In addition, it

possible that the hysteria and fear that typically accompanies disease outbreaks might contribute to an overuse of antibiotics and make campaigns to convince the public to take measures against antibiotic use less effective. Disease outbreaks are highly emotionally-charged events in which fear-mongering can overstate the level of danger involved (Luckerson, 2014) and Oh et al. (2013) found evidence to support the notion that more anxiety-laden tweets contributed in spreading rumors in such crisis situations.

Outbreak events are also likely to be more accessible in the minds of the public when they are faced with illness. Availability heuristics might explain this phenomenon (Keller, Siegrist, & Gutscher, 2006), whereby the possibility of contracting a life-threatening disease seems much more likely than in reality. Unfortunately, social media websites such as Twitter and Facebook might play into the mass hysteria surrounding disease outbreaks (Luckerson, 2014), ultimately contributing to an overall lack of understanding about AMR and the nature of medicinal treatments.

2.2. Combating misinformation online

At the same time, some have argued that the very features of computer-mediated communication that might accelerate the spread of misinformation might actually contribute in combatting rumor-mongering. While the internet essentially allows anyone and everyone to contribute content and potentially spread misinformation, this can also create an inherently egalitarian and democratic space in which to discuss issues (Barlow, 1996; Halpern & Gibbs, 2013; Katz, 1998). With physical distance and a degree of invisibility, the internet can afford a minimization of status and authority (Suler, 2004), which might invite user input more equally across groups of different status.

Particularly in cases where users are anonymous, this might have a disinhibiting effect on users (Suler, 2004) perhaps increasing the likelihood that they would speak out against information they believe not to be true. For example, in an analysis of Facebook comments on the White House page, Halpern and Gibbs (2013) found that this social media platform was successful in democratizing discussion, allowing information to be spread widely to various social circles while enabling “more symmetrical conversations among users” (p. 1159). Thus, social media might present some affordances in that it evens the playing field and invites equal participation across users.

Moreover, while Garrett (2011) has argued that the internet can allow misinformation to spread, he maintains that the internet dually functions as a means of disseminating rumor rebuttals. As such, he further provided evidence to suggest that this occurred online in the context of political rumoring surrounding the 2008 presidential election and, moreover, Garrett (2011) suggested that online worlds might actually de-incentivize the creation of lies and rumors because other users have the ability to fact-check and verify their assertions. In this case, some users might hesitate to post information online that may not be accurate for fear that others will accuse them of lying or simply being wrong.

There are also some cases in which the rapid spread of information on the internet, and social media in particular, might prove beneficial to public health. For example, there have been successful efforts employed over social media to spread information regarding food recalls and other health risks (Rutsaert et al., 2013). As another example, the Center for Disease Control and Prevention (CDC) effectively communicated information regarding a 2009 Salmonella outbreak via social media including Facebook, Twitter, online video-sharing sites, podcasts, and blogs. To wit, the CDC even launched an internet-based widget that allowed users to determine whether their food items were contaminated. In this instance, the authors wrote, “The use of social media in the salmonella outbreak enabled greater public awareness of the outbreak and made it possible for the public to be involved in the dissemination of information and thus, become actively involved in communication efforts during the crisis” (p. 87). As such, the public’s role in spreading news of the outbreak was essential to the campaign’s success.

Examples such as these ones thus indicate that social media and the rapid spread of information that it affords can be harnessed to benefit public health, as long as it is implemented properly. This position also offers an interesting counterpoint to Oh et al.'s (2013) discussion of rumors spreading in crisis situations via Twitter. Clearly, a tension exists in attempting to determine how to maximize the possibility that information circulating online remains accurate and does not unintentionally incite panic.

2.3. Factoring fatalism in to mediated (mis)information

Unfortunately, even when users are presented with perfectly accurate information regarding a public health risk, personality factors might induce them to ignore or downplay the warning. Most notably, fatalism is a personality construct that might influence users to react irrationally when faced with threatening information or to disregard it as personally irrelevant. Fatalism is defined as “the belief in a lack of personal power or control over destiny or fate,” and has historically been applied to the health sciences to explain why some people fail to prevent or alleviate health issues (Drew & Schoenberg, 2011).

For example, Straughan and Seow (1998) found that individuals' tendencies toward fatalism impacted their perceived self-efficacy. Due to a reduced sense of self-efficacy, those with higher fatalism scores also tended to be less open to cancer screening procedures (e.g. mammography, self-examinations, etc.). One way that fatalism might apply to AMR is in cases where people are unwilling to get vaccinated for seasonal illnesses. Faced with campaigns that advise them to prevent getting the flu, those with fatalistic tendencies may assume the message does not apply to them or feel that it is out of their control, both leading to inaction.

Thus, there exists a major problem in that, even when people with a more fatalistic disposition have a general understanding of the issue at hand with AMR, they may be less willing to accept their personal role in the problem. Instead, many such individuals may consider themselves at low risk for AMR, and place the blame and responsibility for alleviating the problem on hypothetical “others” and clinicians (McCullough et al., 2016).

Moreover, some of the research on fatalism in health contexts has suggested that certain groups of people are more susceptible to fatalistic values than others. There may be other cultural factors at play, however, such as “access to services, competing priorities, and inadequate knowledge” (Drew & Schoenberg, 2011). The study reported here thus hopes to better understand how fatalism and other demographic variables might impact misinformation and misbehaviors regarding antibiotic usage. In the context of increasing social media use, and the uncertain and still widely debated role of that information and its uses, certain of these variables might intersect in exacerbating a vicious cycle of misunderstanding surrounding AMR.

This study therefore proceeds to advance the following research questions, which examine the extent to which differing factors of media consumption and creation, as these relate to other germane personal characteristics may contribute to not only AMR misinformation but also the misuse of AMR-related products.

RQ1: How many individuals demonstrate high levels of AMR misinformation, misuse, and which characteristics are related to those erroneous beliefs and behaviors?

RQ2: Does the increased *consumption* of certain media relate positively to increasing the likelihood that individuals will have high levels of AMR misinformation and misuse?

RQ3: Does the increased *creation* of content on social media relate positively to increasing the likelihood that individuals will have high levels of AMR misinformation and misuse?

RQ4: To what extent does increased media use interact with holding more fatalistic viewpoints to contribute to relatively higher levels of AMR misinformation and misuse?

3. Methods

This study fielded a sample of 1,321 online opt-in panel respondents that were generally well-matched to the US Census figures along gender, age, education, and income parameters. Along those lines, 51% of respondents were female, the median age was 40 years ($M = 43.02$, $SD = 16.31$) with youngest being 18 and the oldest 87. In terms of age groups, 12.8% were 18–24, 42.7% were 25–44, 30.1% were 45–64, and the remaining 14.5% were aged 65 years or older. Consistent with the general breakdowns by income and ethnicity in the most recent US census, 23.7% earned \$24,999 or less, 30.2% made between \$25,000 and \$49,999, 33.1% were in the \$50,000 to \$99,999 income bracket, and 13% reported earning \$100,000 or more. Here, 68.1% of respondents were Caucasian, 14.7% were African American, 10.4% Hispanic / Latino, 4.6% were Asian, and just under 1% indicated being either Native American or Pacific Islanders.

Education wise, there were just 2.6% of respondents with an education level less than high school, 21.0% identified earning a high school diploma or GED as their highest level of formal educational attainment. There were 32.3% of respondents with some college, 12.6% with a two-year college degree, 21.6% with a four-year college degree, and 9.9% had earned some form of advanced or post-graduate degree. Of course, despite efforts to achieve a fully representative and perfectly generalizable sample, we note that there are some limitations for online panels in that regard (Peifer & Garrett, 2014) but also identify that such stratified online quota samples are contemporarily being used similarly in the discipline (c.f. Gil de Zúñiga, Garcia-Perdomo, & McGregor, 2015).

Respondents answered a total of 39 questions about their media use, including traditional (television, radio, print) media consumption along with their consumption and creation of content online as well as their reliance on social networking sites for news and information. Here, items that measured frequency of use were set on an ordinal 0–4 scale that ranged from “never” to “all the time.” Using varimax rotation in factor analysis, nine items comprised consumption of traditional news media including television networks, radio, and newspapers (Cronbach’s alpha [α] = .861). There were then six items regarding the frequency of consuming online media (e.g. watching YouTube videos, reading online comments, reading blogs) loaded strongly as a factor of online media consumption ($\alpha = .860$). Similarly, seven more items measured the frequency with which respondents create and share online media in more active ways, such as posting their own comments, uploading photos/videos, or contributing to forums or wikis ($\alpha = .922$).

In terms of media items, there were also three questions that in factor analysis indicated the extent to which participants rely on social networking sites for news and information. These items were on a 1–5 scale from “strongly disagree” to 5 “strongly agree” and had a reliability score of $\alpha = .703$, indicating an acceptable reliability level.

A series of attitude statements assessed how participants think and behave regarding anti-microbial resistance, antibiotics, and germ-fighting products. All of these questions were also on an ordinal 1–5 scale of “strongly disagree - strongly agree.” Five items loaded highly in assessing misinformation about anti-microbial resistance with statements that reflected common misconceptions about this topic. Specifically, the correct answer to these items based on medical research was to “disagree” and included “Older people should take antibiotics like penicillin every day to maintain good health” ($M = 2.03$, $SD = 1.15$), “If I could, I’d take antibiotics like penicillin every day to protect my health” ($M = 1.89$, $SD = 1.12$), “Antibiotics are effective against cold and flu” ($M = 2.71$, $SD = 1.29$), “Antibiotics are effective against viruses” ($M = 2.98$, $SD = 1.34$), and “Taking antibiotics often has side effects” (which was reverse coded as a control; $M = 2.43$, $SD = .97$). “Agreeing” or “Strongly Agreeing” with these false statements indicated higher levels of overall misinformation ($\alpha = .729$), whereas “Disagreeing” or “Strongly Disagreeing” demonstrated respondents being more accurately about AMR.

Along the same lines, respondents also answered three items on the same 1–5 scale of “strongly disagree” to “strongly agree” that loaded together to indicate misbehaviors regarding the use of antibiotics ($\alpha = .876$) where the correct medical use was to “disagree” or “strongly disagree” with the indicated activity. This factor thus comprised the following: “Whenever I get antibiotics to treat a problem, I don’t finish them all so I have some for later use” ($M = 2.13$, $SD = 1.18$), “I stop taking antibiotics as soon as I feel better, even if I have some pills left over” ($M = 2.22$, $SD = 1.26$), and “I keep antibiotics on hand just in case I or my family might need them” ($M = 2.22$, $SD = 1.25$). While it is clear respondents reacted similarly to these items as they did with the misinformation items, it is worthwhile to note that the correlation between these two key variables only achieved a Pearson’s r correlational coefficient of .55 ($p < .001$), which suggests that there is a moderately strong but not overlapping linkage in respondents that are more misinformed about AMR and those that misuse AMR products.

In addition to the items about AMR, this study also incorporated identical 1–5 scales of “strongly disagree - strongly agree” responses that measured respondents’ communication confidence (an inverse of communication apprehension; $\alpha = .800$), innovativeness ($\alpha = .729$), and overall life satisfaction ($\alpha = .727$). Two additional attitude statements examined fatalism, or the extent to which participants believe that fate dictates their life and they are largely not in control ($\alpha = .717$). These indices were based on previously validated measures for each construct (cf., Hurt, Joseph, & Cook, 1977; McCroskey, 1982).

Relationships between variables were determined using chi-square tests and logistic regressions. Additional context-specific details are provided in the findings section.

4. Findings

This study began by exploring RQ1 and which characteristics and attitude related to greater incidence of AMR misinformation and misuse with percentage breakdowns of demographic variables. In these analyses, being misinformed about AMR and having misused antimicrobial-related products was set as a binary proposition where respondents that scored less than the mean on each scale were considered to have a “low” level of AMR misinformation ($M = 2.41$, $SD = .82$) and misuse ($M = 2.19$, $SD = 1.10$), and those individuals that scored higher than the respective means were at a “high” level for both. Such transformation is relatively common in media research and sets a bar that is accurate in assessing AMR misinformation and misuse relative to the public understanding. In addition, the mean and the median were nearly identical and so we feel these dummy variables maximize the available data for the purpose of generalizing to the broader American population as a whole.

Once applied, 46.9% of the sample could be considered highly misinformed about AMR and 42.2% of respondents demonstrated a high level of misusing AMR-related products. Within these percentages it was clear that younger age groups were more misinformed (from 62.7% of those aged 18–24) than older cohorts (which declined consistently to 29.8% of respondents aged 65 and over). This difference was statistically significant ($\chi^2(df: 3) = 49.67$, $p < .001$) and the same pattern was found for AMR misuse ($\chi^2(df: 3) = 80.87$, $p < .001$), with the greatest amount (61.5%) of 18–24 year olds and (49.1%) of 25–44 year olds having demonstrated high levels of AMR misuse, compared to 34.3% of 45–64 year olds and 21.5% of respondents 65 or older.

When looking at gender, it was clear that a greater percentage of males (55.5%) than females (38.6%) had high levels of AMR misinformation ($\chi^2(df: 1) = 37.91$, $p < .001$). In terms of AMR-related product misuse, significantly ($\chi^2(df: 1) = 34.49$, $p < .001$) more males (50.4%) than females (34.4%) reported high levels, suggesting that gender is an important determinant in AMR knowledge and behavior.

The relative percentages of different ethnicities and AMR misinformation also were statistically significant (χ^2 (df: 4) = 58.85, $p < .001$), with – in descending order – 67.5% of African Americans in this sample reporting high levels, compared to 57.4% of Asian and 56.9% of Hispanic / Latino respondents, 51.7% of Native American / Pacific Islanders or Other ethnicities, and 40.0% of Caucasian respondents. The relative distributions of high AMR misuse were likewise significant (χ^2 (df: 4) = 30.31, $p < .001$) but much differently comprised. Again, presented from groups with greatest to least percentages, high misuse was most frequent (62.1%) among Native American / Pacific Islanders or Other ethnicities, followed by 53.3% of Hispanic / Latinos in this sample, 52.5% of Asian respondents, and 51.5% of African Americans and 37.2% of Caucasian respondents.

There was no statistically significant difference in AMR misinformation (χ^2 (df: 3) = 6.12, $p = .11$) or the misuse of AMR-related products (χ^2 (df: 3) = 4.64, $p = .20$). Nonetheless, it was somewhat interesting to note that the higher income bracket of \$50,000 to \$99,999 in annual income had the greatest percentage of high AMR misuse, with 45.3%, and there were 40.7% of the highest income bracket (earning \$100,000 or over) that showed high levels of AMR misuse. Education levels were also cross-tabulated and showed statistically significant differences for AMR misinformation (χ^2 (df: 5) = 27.26, $p < .001$), where increasingly higher education levels showed increasingly less misinformation, with a low of 36.6% of those holding advanced post-graduate degrees to 61.8% of respondents that had not graduated from high school. There was no statistically significant difference across education levels for AMR misuse (χ^2 (df: 5) = 7.58, $p = .181$).

Next, in jointly examining RQ2 and RQ3, using a series of logistic regression models, this study was able to estimate the likelihood that respondents with certain characteristics either were misinformed about AMR or did not behave in accordance with recommended AMR guidelines for products such as prescription drugs and antibacterial soaps. Importantly, these regressions build on demographic measures as well as introduce and control for additional personal characteristic variables, including indexes of communication confidence ($M = 3.44$, $SD = .96$), innovativeness ($M = 3.69$, $SD = .65$), life satisfaction ($M = 3.25$, $SD = .88$), and fatalism ($M = 2.52$, $SD = 1.03$).

A set of media usage scales were also included for analyzing RQ2 by separately considering consuming traditional media ($M = 1.71$, $SD = .84$), consuming online media ($M = 1.95$, $SD = .91$) and relying on social media as a news source ($M = 2.84$, $SD = .94$). The relationship presented by RQ3 was examined by incorporating the frequency of creating and sharing online media variable ($M = 1.57$, $SD = 1.05$).

In the first of these models, which examined the likelihood that respondents would have a high level of AMR misinformation, there were a number of key findings that shed additional light on the relative importance of factors that shaped this outcome. In this analysis, being male increased the likelihood of being highly misinformed about antimicrobial resistance significantly ($Exp(B) = 2.12$, $p < .001$), as did being African American ($Exp(B) = 2.19$, $p < .05$). The only other statistically significant personal characteristic that increased AMR misinformation was having higher levels of fatalism ($Exp(B) = 1.32$, $p < .001$), where each increasing level of fatalism was corresponded to being 1.32 times more likely to be highly misinformed about AMR. Alternately, each additional year of age decreased the likelihood of being high AMR misinformation by a factor of .98 ($Exp(B) = .98$, $p < .001$), and each additional level of formal education achieved was related to a similar decline ($Exp(B) = .85$, $p < .01$) in AMR misinformation.

Unsurprisingly, those respondents that reported more misuse of AMR-related products just more than twice as likely ($Exp(B) = 2.03$, $p < .001$) to be highly misinformed about AMR. In terms of media factors, respondents that consumed (RQ2) traditional media more frequently were 1.48 times ($p < .001$) more likely to have high AMR misinformation levels as consumption increased from zero (never) to four (all of the time). In addition, consuming more online media was significantly related to being *decreasing* the likelihood of being highly misinformed about AMR ($Exp(B) = .79$, $p < .05$) yet heavier reliance on social network sites for news was not significant ($Exp(B) = 1.14$, $p = .14$). In this

model, though, (RQ3) showed that more frequently creating and sharing online media ($Exp(B) = 1.27$, $p < .05$) positively related to the likelihood of respondents being highly misinformed about AMR.

Taken together, these findings suggest a differentiation in users that rely more on traditional or online media as sources of information, and regardless those consumptive activities, for each increase in respondents more regularly posting and sharing information online are 1.27 times more likely to be highly misinformed themselves. These findings, which situate media use among the most vital in predicting AMR misinformation levels are summarized in Table 1.

In the second regression modelled, the likelihood of respondents indicating a high level of misusing AMR-related products was examined in relation to the same factors already reported, with the exception of adding AMR misinformation to model in place of AMR misuse to avoid perfect collinearity. Here, each increasing level of AMR misinformation was associated with respondents being 2.80 times more likely ($p < .001$) to misuse AMR-related products.

Further, in this analysis, being male was again significantly related to high AMR misuse ($Exp(B) = 1.93$, $p > .001$), and each year of additional age decreased that likelihood just marginally ($Exp(B) = .97$, $p < .001$). Other significant personal factors include higher income levels ($Exp(B) = 1.15$, $p < .10$) as well as higher levels of innovativeness ($Exp(B) = .67$, $p < .05$) and greater life satisfaction ($Exp(B) = 0.84$, $p < .05$), which both decreased the odds of high AMR misuse. Yet, as with the previous model, increased fatalism predicted a greater likelihood of respondents having a high level of AMR misuse ($Exp(B) = 1.50$, $p < .001$).

In terms of information channels, each additional level of traditional media consumption (RQ2) was related to a statistically significant increase of respondents being 1.30 times more likely ($p < .01$). Unlike the model on AMR misinformation, none of the other media factors were statistically significant in relation to increasing the likelihood of high AMR misuse. Specifically, this outcome was unrelated to the (RQ2) consumption of online media ($Exp(B) = .87$, $p = .37$) or the increased reliance on social network sites for news ($Exp(B) = 1.32$, $p < .05$) as well as the (RQ3) creating and sharing through online media ($Exp(B) = 1.20$, $p = .178$). Altogether, these results again reinforce that there are important implications for the misuses of AMR-related products that are being shaped by consumers of traditional media channels, and the influence of this media factor remains crucial even when taking into account extant AMR misinformation among the general public. Results are again summarized in Table 1.

Based on these findings, and the fact that fatalism was a key factor in both AMR misinformation and misuse, this study next proceeded to examine RQ4 and the intersection of fatalism and different media variables as joint explanatory factors of AMR misinformation and misuse. In a series of factorial ANOVAs there were uniformly statistically significant interactions where, when fatalism was set as a binary of low and high conditions against ordinal five-point rankings of media use, those respondents with high fatalism and higher levels media use always showed the highest levels of AMR misinformation and misuse.

One example is of AMR misinformation, with a statistically significant interaction ($F(1, 1311) = 7.86$, $p < .001$, partial $\eta^2 = .023$) between traditional media consumption and fatalism in which the average level of AMR misinformation is 2.23 (SD = .69) for low fatalism and the lowest consumption level of traditional media, which increases to 3.00 (SD = .38) among those with low fatalism but the highest level of traditional media use. Interestingly, the lowest average among high fatalism respondents is 2.26 (SD = .82) for those that report being the least frequent consumers of traditional media – but that average drastically increases to 3.56 (SD = .87) among high fatalism respondents that are also the heaviest consumers of traditional media.

This relationship is graphed visually in Figure 1, and is representative of statistically significant AMR misinformation interactions with fatalism and online media consumption ($F(1, 1311) = 7.46$,

Table 1. Logistic regression models for the likelihood of being misinformed about AMR and misusing AMR-related products

		AMR misinformed		AMR misuse	
		Odds ratio	Std. err.	Odds ratio	Std. err.
Age		.980	.005	.970**	.005
Being male		2.121***	.147	1.93***	.147
Caucasian		.751	.266	.671	.264
African Amer.		2.185*	.311	.739	.308
Hispanic/Latino		.881	.323	.792	.321
Income		.873#	.076	1.152#	.076
Education		.849**	.056	.975	.056
Com. confidence		.926	.083	1.007	.084
Innovativeness		.814	.128	.673**	.127
Life satisfact.		1.140	.083	.836*	.084
Fatalism		1.320***	.072	1.354***	.073
Consume offline		1.481***	.100	1.304**	.099
Consume online		.794*	.116	.982	.115
Create online		1.268*	.106	1.104	.104
Rely SNS news		1.138	.087	1.094	.087
AMR misuse		2.027***	.074	-	-
AMR misinformed		-	-	2.800***	.105
Constant		2.188	1.329	.031*	1.361
Pseudo R ²		.382		.371	
N		1321		1321	

#*p* < .10
 **p* < .05
 ***p* < .01
 ****p* < .001.

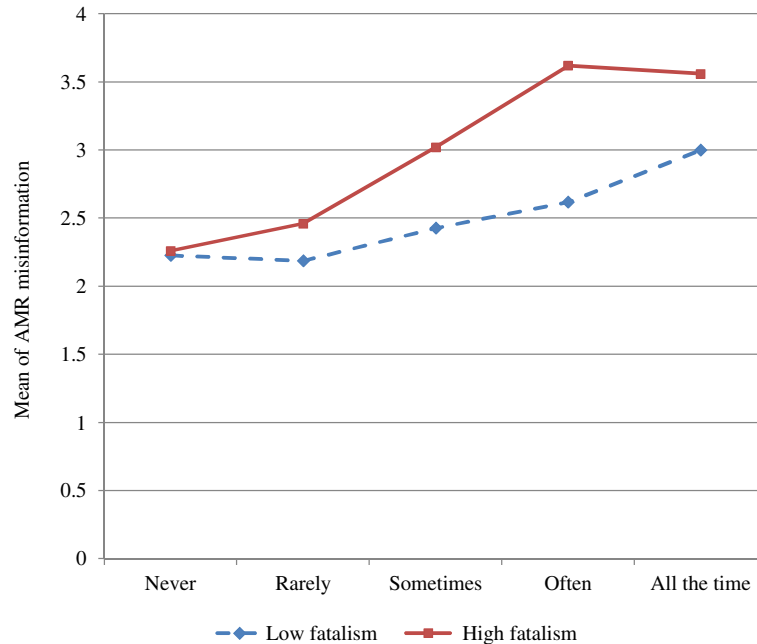
p < .001, partial $\eta^2 = .022$), relying on social network sites for news ($F(1, 1311) = 8.55, p < .001$, partial $\eta^2 = .025$), and creating online media ($F(1, 1311) = 8.13, p < .001$, partial $\eta^2 = .024$). These results uniformly point to the fact that increasing levels of media use and their impact on AMR misinformation are moderated by the fatalism reported by respondents.

Continuing, and perhaps unsurprisingly, nearly identical patterns of statistically significant interactions were also found for average levels of misusing AMR-related products with fatalism and traditional media consumption ($F(1, 1311) = 17.04, p < .001$, partial $\eta^2 = .049$), online media consumption ($F(1, 1311) = 7.55, p < .001$, partial $\eta^2 = .023$), relying on social network sites for news ($F(1, 1311) = 15.43, p < .001$, partial $\eta^2 = .045$), and more frequent creating and sharing of online media ($F(1, 1311) = 8.92, p < .001$, partial $\eta^2 = .027$). Taken together with the results of the regression models and the previous interactions on AMR misinformation, these findings certainly suggest that both fatalism and differing forms of media use are central to increased AMR misinformation and the misuse of AMR-related products.

5. Discussion and conclusion

Broadly speaking, these results begin to identify the myriad ways in which media consumption and usage are related to the increased incidence of misinformation about antimicrobial resistance as well as the misuse of AMR-related products among the general public (cf., Curry et al., 2006; Perz et al., 2002). In specific, this study outlines how increased consumption of traditional media is linked to a greater likelihood of both AMR misinformation and misuse, even when controlling for the

Figure 1. Interaction between average levels of AMR misinformation, traditional media consumption, and fatalism.



endogenous relationship among these AMR measures. Social media creation was also shown to be a potent factor in increasing AMR misinformation, whereas the consumption of online media actually was related to a decrease in that outcome, which contrasts the work of Acemoglu et al. (2010).

Put somewhat briefly, these findings indicate that traditional media remains a crucial source content that seems to link to AMR misinformation, and those that post more regularly to online media, such as wikis and other types of social media, are increasingly likely to hold (and share) incorrect information on AMR. This propensity for sharing “wrongly” is then reflected in the fact that those respondents that share and create more on social media exhibit greater likelihoods of being misinformed about AMR (Baumeister & Finkel, 2010; Metaxas & Mustafaraj, 2010; Sunstein, 2002). To some extent, the confluence of these findings suggests a misinformation cycle whereby traditional media exposure may well connect with increased posting of potentially misinformed content about AMR to social media, even though those that rely more online media actually showed a decreased likelihood of being AMR misinformed.

Moreover, in all of the factorial ANOVAs reported here, the higher media conditions statistically significantly increased both misinformation and misuse outcomes, specifically where respondent levels of fatalism were also high. This suggests that there is a certain intersection of stable conditions, such as fatalism, that normally predict AMR misinformation and misuse that is being augmented by traditional and online media consumption, social media activity, and reliance on social networking sites (Garrett, 2011; Keller et al., 2006).

Though the data from this study is cross-sectional and thus introduces limitations to establishing causality, when taken together, the findings reported here nonetheless suggest that antimicrobial resistance will need to be addressed with an especially keen focus on user-generated social media to mitigate the circulation of misinformation and stem the incidence of AMR misinformation and misuse. That sort of activity can take place at multiple levels, from broad health organizational initiatives to direct social media outreach from physician offices but the so-called backchannel (Harrington, Highfield, & Bruns, 2013) of online and social media simply cannot be ignored for AMR, because as this study demonstrates, it is a significant factor in shaping public knowledge and behaviors.

From a practical standpoint, this study is one of few, and perhaps the first to take on the call of Smith et al. (2015) in forging some pathways forward in better understanding attitudes and behaviors regarding AMR and how to approach challenging misinformation and misuse observed here. In addition, from a more theoretical standpoint, this study not only establishes important differentiations between media channels and consumption (Garrett, 2011) but also concepts of reinforcement through content creation and increased reliance on social media for news and information, which advances a richer understanding of media affordances (Katz, 1998) in the context of a vitally important global health risk.

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The authors declare no competing interest.

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