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The Ten Commandments of Antibiotic Stewards

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# ONE HEALTH CASES

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## The Ten Commandments of Antibiotic Stewards

Antibiotic resistance is an emergency for global health security, the solution for which demands a transdisciplinary and interprofessional One Health approach. This case study builds on a project to recruit antibiotic stewards and examines their responsibility to disseminate best practices, to support deeper knowledge, conservative attitudes and preventive practices.

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## Summary

Antibiotic resistance is an emergency for global health security, the solution for which demands a transdisciplinary and interprofessional One Health approach. This case study builds on a project to recruit antibiotic stewards and examines their responsibility to disseminate best practices, to support deeper knowledge, conservative attitudes and preventive practices.

## Abstract

Antibiotic resistance is a global emergency that threatens the reversal of improvements in societal capacity to reduce human mortality caused by infectious pathogenic bacteria. Solutions to the problem demand a One Health approach because antibiotics are abused in animal and human healthcare; and the emergence and spread of resistant pathogens occurs in environmental contexts. In all regions of the world, antibiotic resistance increases the global burden of diseases by jeopardizing population health, food security and environmental quality, with most of the adverse impacts expected in Africa. Proposed remediation strategies hinge on improving antibiotic stewardship through deeper knowledge of social and ecological determinants of resistance, conservative attitudes in antibiotic uses, and preventive practices to curb infectious diseases. This case study is based on a project entitled Antibiotic Stewardship is Public Health (ASPH), with the goal of empowering stewards with tools to implement strategies for preventing antibiotic-resistant infections. The Ten Commandments of antibiotic stewards emerged from population surveys, stakeholder interviews and community engagement exercises. Outcomes were distilled to inform best practices including: using antibiotics as prescribed; not disposing of expired antibiotics in domestic waste; advocating prudent use of antibiotics in farm animals; supporting research to respond better to antibiotic resistance; teaching students about the importance of antibiotics for global health security; understanding the One Health approach to combatting antibiotic resistance; advocating effective policies to stop the careless use and disposal of antibiotics; resisting consumption of food items laden with antibiotic residues; and supporting research to discover alternative therapies to prevent or treat infections.

# What Is the Incremental Value that Makes This a One Health Case?

This case study codifies some universally applicable best practices for improving antibiotics stewardship through education and advocacy to reduce the abuse of antibiotics in human healthcare and agricultural practices, whilst also reducing environmental contamination resulting from improper disposal of expired antibiotics. The case promotes a One Health approach to stimulate behaviour change and communication of best practices to lighten the burden imposed by antibiotic-resistant infections on human populations. The recruitment of antibiotic stewards can be replicated regionally and globally to generate the momentum needed to curb the adverse impacts of antibiotic-resistant pathogens worldwide.

## Learning Outcomes

1. The One Health approach to curbing the impacts of antibiotic resistance addresses gaps in knowledge and attitudes about multisectoral sources of resistant pathogens in the context of excessive antibiotic prescriptions in human healthcare, misuse of antibiotics by patients, prophylactic use of antibiotics in animal care and agricultural practices, antibiotic residues in consumer food products, and ecosystem pollution by antibiotics in wastewater.
2. The outcome of assessments of knowledge, practices and attitudes regarding antibiotics and their appropriate use varies across individuals and populations and provides opportunities to target educational and information campaigns with the goal of promoting improvement and scope of antibiotic stewardship.
3. In communities of adolescents transitioning from paediatric care to independent healthcare, recruitment of antibiotic stewards can promote awareness of best practices regarding antibiotics through social networks and digital media campaigns.

## Background and Context

### 1. Rationale

An authoritative review of antimicrobial resistance (AMR) projected that if the scourge is not tackled now, one human death from this cause will result every three seconds by the year 2050.<sup>1</sup> The death toll will have increased from the current 700,000 to 10 million annually at a cost of US\$100 trillion in global production. In May 2015, the 68th World Health Assembly endorsed a global action plan to tackle antimicrobial resistance. Further, in September 2016, at the United Nations General Assembly meeting, all nations committed to address the emergence and spread of AMR. Bacterial antimicrobial resistance (BAMR), also referred to as 'antibiotic resistance', is perhaps the most daunting challenge because of the large historical burden of disease attributed to bacterial pathogens and the threats posed to food supply, recreation, international transportation and lack of effective vaccines for many such pathogens. The United Nations' declaration acknowledged that within the broader context of AMR, resistance to antibiotics, which specifically target bacteria, is the greatest and most urgent global risk, requiring increased attention and coherence at the international, national and regional levels.<sup>2</sup> For example, in the United States, 2 million illnesses and 23,000 deaths, annually, are caused by antibiotic-resistant bacteria. The African subcontinent (SSA) is expected to bear a particularly heavy burden of disease due to failing antibiotic therapy. The 2019 assessment of the global burden of BAMR identified SSA as the region with the highest all-age mortality rate, with 27.3 deaths per 100,000 (20.9–35.3). Moreover, The difference between the region with the lowest burden of BAMR, Australasia, and the highest burden, SSA, is more than four-fold.<sup>3</sup> Improving stewardship of antibiotics is a multisectoral challenge, encompassing several professions and academic disciplines, including agriculture, medicine, nursing, pharmacy, environmental science, behavioural science, and community engagement. Therefore, comprehensive interventions are best situated in the One Health framework, defined as 'an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems'.<sup>4</sup> Working within this One Health framework, our international interdisciplinary team embarked on a project entitled Antibiotic Stewardship is Public Health (ASPH), with imperative actions for public education, effective translation of knowledge into action and fail-proof implementation of best practices, globally. These imperatives became the foundation of the ASPH project, which built on the

research to improve understanding of public knowledge, attitudes and practices of antibiotics stewardship in population samples and among stakeholders of Ghana's Action Plan on Antibiotic Resistance.<sup>5,6,7</sup> We used the World Health Organization's multi-country survey of awareness of antibiotic resistance to assess variations in public perception, attitudes and practices according to occupation – urban compared to rural dwelling, gender, and level of education.<sup>8</sup> We also surveyed adolescent and young adult college students to identify opportunities to bolster targeted educational intervention programmes at the cusp of transition from paediatric to adult healthcare systems. We sought to identify impediments to action through the framework of implementation science, and to use community engagement techniques to develop and implement sustainable actions through the recruitment of antibiotic stewards.

## 2. Goals and outcomes

This case study has three major goals: (i) to explore knowledge, attitudes and practices regarding antibiotics in different populations; (ii) to distill data gathered from international surveys through a One Health framework into pledges for recruited antibiotic stewards who are equipped to educate, advocate and disseminate credible information about antibiotic resistance and best practices for antibiotic stewardship; and (iii) to support a virtual community of practice on antibiotics stewardship to generate a global momentum and engage a variety of stakeholders.

## 3. Target audience

A public recruitment campaign with a wide range of printed and digital paraphernalia, including fliers, pin buttons, t-shirts and advertisements in social media including Twitter (see: [https://mobile.twitter.com/asph\\_uci](https://mobile.twitter.com/asph_uci)); Facebook (see: <https://www.facebook.com/groups/186817913591982/>) and Instagram was targeted to the general public and university students. The local chapter of the International Student One Health Association (ISOHA) assisted in dissemination invitations to members about the TIPH programme (see: [https://instagram.com/isoha\\_uci?utm\\_medium=copy\\_link](https://instagram.com/isoha_uci?utm_medium=copy_link)) with outreach to approximately 1000 individuals. Overall, the audience of recruited antibiotic stewards were college-educated individuals on all continents with intentional focus on the USA, Ghana and Senegal.

## 4. Activities for implementation

### Survey of knowledge, beliefs, attitudes and practice

In order to change behaviours that lead to the emergence and spread of antibiotic-resistant pathogens, it is important to first understand what individuals know about antibiotics and in which ways they encounter and use them. Depending on the information gathered about baseline behaviours regarding antibiotics, it should be possible to design and implement interventions such as public education and communication campaigns that are expected to effect behavioural change. Since 2008, when the World Health Organization collaborated with the tuberculosis (TB) partnership to publish a set of guidelines for countries to assess their populations' knowledge, beliefs, attitudes and practices about antibiotics, surveys have been conducted in populations in many countries and across various communities, professional occupations and patient groups.<sup>9,10</sup> To be most useful, the outcome of such surveys should reveal commonalities and specific differences that may pinpoint best approaches to disseminating public health messages regarding antibiotics. The adolescent population transitioning from paediatric care and parental oversight of food purchases to adult healthcare and relative independent decision making regarding food, seems to be a population vulnerable to disinformation about antibiotics and presents an opportunity to intervene with dissemination of best practices regarding proper antibiotic use. Disseminating public health information through peers in a social network has generated renewed interest among researchers and practitioners because of the broad reach of internet resources and the role of influencers or information champions.<sup>11</sup>

In this case study, we were interested in understanding the behaviours of adolescents regarding antibiotics and to rely on the deeper understanding for developing a social network and digital media campaign through appointment of antibiotic stewards and the engagement of transdisciplinary sectors in healthcare, food production and environment sectors, consistent with the One Health framework. We also hypothesized that the case study process could be replicated in various communities, globally, with modifications to accommodate local idiosyncrasies and public health priorities. Therefore, we sought to identify potential antibiotic stewards and opportunities to codify the messaging to improve stewardship by administering

a survey on knowledge, attitudes and practices regarding antibiotics, and we reviewed and analyzed the responses. We extracted a set of best-practice mementos, which were subsequently administered as a pledge to designated antibiotic stewards and disseminated through internet facilities.<sup>12</sup> The case study used a slightly modified version of the World Health Organization's *Antibiotic Resistance: Multi-Country Public Awareness Survey* questionnaire,<sup>13</sup> whereby we included questions such as knowledge of meat raised without antibiotics and payment for therapy and medicines. The questionnaire included 36 questions targeting individual knowledge, attitudes and practices, consisting of both nominal and ordinal closed questions on participant demographics (8 items), access and use of antibiotics (10 items) and knowledge and perceptions about antibiotics and antibiotic resistance (18 items). The case study protocol was reviewed and approved by the Institutional Review Board. Participants were recruited through social network platforms, Facebook group chats and LoopChat. A total of 211 questionnaires were completed with approximately 50 participants for each category of educational attainment. Each respondent took an average of 30 minutes to answer all the questions. Eligibility was restricted to adults who were aged 18. The survey was released with a follow-up reminder every two weeks, followed by one-week follow-ups during the last three weeks, and more frequent, at 1–3 day intervals, in the LoopChat group. Participants were screened and recruited by a trained researcher. Upon completion of the questionnaire, participants received a \$5 reward gift card and were provided with educational information through an infographic on antibiotic resistance.

Participant knowledge about antibiotics was based on the number of correct responses to 15 questions regarding different infectious diseases that could be treated with antibiotics, three questions relating to knowledge about prudent use of antibiotics, and eight questions about antibiotic resistance. The scores ranged from 0 to 21, with a higher score indicative of a more knowledgeable profile. Attitudes were defined on a Likert scale and determined whether a person agreed strongly, slightly, neither agreed nor disagreed, disagreed slightly, or disagreed strongly, with a set of eight statements regarding one's perceptions about actions to reduce antibiotics. An average score was determined, ranging from 1 to 5. The final dependent variable, *practices*, was based on a total score for three items that assessed appropriate use of antibiotics. We analyzed two independent variables, namely level of academic accomplishment, and gender, using a combination of statistical methods to analyze the data, including chi-square and unadjusted regression analysis, according to previously published research.

## Analyzing and contextualizing information gathered from population surveys

Regarding the domain of knowledge of antibiotics in the population surveyed for this case study, 94.3% of respondents knew that it is inappropriate to consume antibiotics prescribed for someone else, even if the symptoms exhibited by two individuals appear similar. A large majority (86.3%) of respondents also knew that the course of antibiotic therapy should be completed even when disease symptoms dissipate. However, 65.9% of respondents also thought that antibiotics are effective against virus infections, which is a gap in the depth of knowledge about antibiotic functions.

The respondents' attitudes about behaviours to prevent bacterial infections and prudent use of antibiotics is generally beneficial, including 95% of the sample population indicated regularly washing hands, and a slightly lower percentage (89.1%) strongly agree with childhood vaccination against bacterial diseases. However, there was much uncertainty about the use of antibiotics in agriculture with the largest proportion of respondents (33.6%) neither agreeing nor disagreeing about its appropriateness or restriction.

Overall, we found no difference due to the gender of respondents and level of *knowledge* about antibiotics and resistance. However, the level of educational attainment was significantly correlated with knowledge. Respondents with at least two years of university education (average age = 20.1 years) demonstrated 1.93 times better knowledge of antibiotics than those who have yet to undertake any university education (average age = 17.7 years) ( $P < 0.05$ ). *Attitudes* toward antibiotic stewardship varied significantly by gender, as males have 0.17 times lower attitude scores than females ( $P < 0.05$ ). We found no significant difference in *practice* of antibiotic stewardship across gender or educational attainment. Therefore, we concluded that to improve antibiotic stewardship in this population, educational interventions and communication campaigns might be effective to improve knowledge and attitudes about antibiotics if such campaigns begin after adolescents transition from paediatric care to adulthood, and to address gender gaps in attitude.

## Identifying targets of opportunity for improving antibiotic stewardship

We then compared these results with the results of a similar study that we conducted in the general population in two regions of Ghana,<sup>7</sup> and we reviewed the outcome of the World Health Organization's multi-country study of antibiotic knowledge, beliefs, attitudes and practices<sup>13</sup> to distill the most likely impactful

pledges of effective antibiotic stewards, which we termed the 'Ten Commandments of antibiotic stewards'. In the survey that we conducted in Ghana, we recruited 400 residents of the Greater Accra and Upper West regions of Ghana. We also restricted participation to those older than 18 who had previously used antibiotics. We used the WHO questionnaire and analyzed data with principal component and multivariate statistical methods to assess various components of pre-existing knowledge and their association with antibiotic use. We identified two principal components, namely knowledge about treatment of common illnesses and knowledge about prudent use of antibiotics. As with the Irvine case study, we found a significant association between gender and the first component, with women having higher knowledge about the treatment of common diseases such as malaria, headaches and body aches. We also discovered that individuals older than 25 years were more knowledgeable about diseases and pathogens in general than were younger adults aged between 18 and 24. Regarding prudent use of antibiotics, we discovered that older age, higher education, and residence in urban regions predicted better knowledge about the prudent use of antibiotics for bacterial infections. We also found that those with recent experience with antibiotic prescriptions and therapy had better knowledge of prudent antibiotic use, which indicated the influence of education and information to improve stewardship. Following the study, we conducted structured interviews with eight stakeholders who participated in the process of assessing Ghana's capacity for dealing with global health threats including the impacts of antibiotic-resistant infections. The participants worked in the policy, research or practice programmes of Ghana's health sector. Their responses were consistent, being concerned about the spread of antibiotic-resistant pathogens, which is rooted in part to inappropriate use of antibiotics. Ghana's national laws to regulate the sale of antibiotics has not been easy to enforce, and there are gaps in cross-sectoral collaboration, particularly linking the human health mitigation programmes to the animal and environmental sectors through a One Health framework. Overall, the stakeholders strongly supported strategies to strengthen the One Health approach in the implementation of Ghana's National Action Plan to address antibiotic resistance.<sup>6</sup>

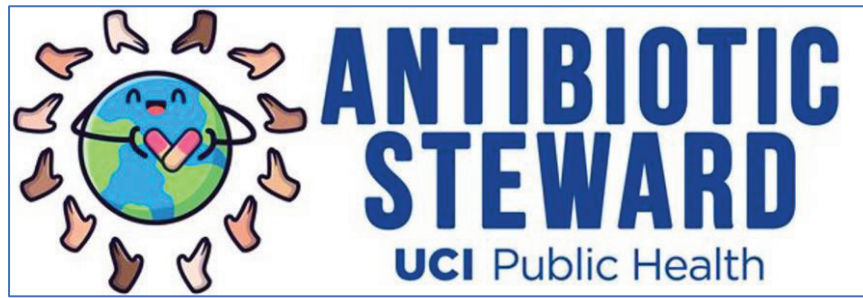
In developing our targets for improving antibiotic stewardship through concise messaging, we also reviewed the outcome of WHO's multinational survey of knowledge, beliefs, attitudes and practice. WHO's recommendations based on survey findings are:

1. to better understand why antibiotics are being used without having been prescribed;
2. to increase public education so that people better understand which conditions can be treated with antibiotics and which cannot (e.g. antibiotics are not effective against colds and flu);
3. why antibiotics should only be taken when they have been prescribed to a specific individual for a particular episode of illness; and
4. the importance of taking the full prescription as prescribed.

Based on these survey results, interviews and WHO recommendations, and in consideration of the intersectoral One Health approach, we included commandments that address knowledge of the environmental context of antibiotic resistance and the problem of antibiotic use in agriculture. Field excursions to nearby grocery stores with embedded pharmacy provided opportunities to learn about antibiotic residues in foods and about the importance of returning expired antibiotics to the pharmacy for proper disposal instead of flushing them down the toilet or disposing of them in domestic waste bins.

## Disseminating best practices

We produced an instructional video to stimulate cross-sectoral thinking about antibiotic resistance according to the One Health framework, and we evaluated the impact of viewing the video on performance improvements regarding the survey of antibiotics knowledge, attitudes and practices. Approximately 400 antibiotic stewards pledged to receive training in antibiotic resistance and to disseminate the knowledge through advocacy. Antibiotic stewards were invited to a Zoom-enabled focus group discussion and invited to receive t-shirts printed with antibiotic steward information, which they are expected to wear to public events to stimulate conversation with a broad audience (Fig. 1). We designed and distributed posters about antibiotic resistance to highlight events held during the global antibiotic awareness week. We distributed ~800 posters, stickers and pins and shared information on antibiotic resistance and stewardship on all our social media handles established specifically for ASPH. We hosted interviews that were published in news media and organized Zoom-enabled workshops to the One Health workforce in Senegal on the integration of antibiotic resistance and stewardship competence into the curriculum for pre-service and in-service workforce and continuing professional development, with about 50 attendees. Presentations to international conferences of the Consortium of Universities for Global Health (CUGH), the International Meeting on Emerging Infectious Diseases (IMED) and the Association of Schools and Programs of Public Health (ASPPH), and a publication in *One Health* journal, also aided in reaching a global audience.



**ANTIBIOTIC STEWARD** UCI Public Health

**STATEWIDE DAY OF ACTION**

MON: November 22nd (1-4 pm PST)  
Location: Zoom

**ANTIBIOTIC STEWARDSHIP IS PUBLIC HEALTH!**




Sign-up here!  
<https://bit.ly/3qN3gTF>

**ANTIBIOTIC STEWARD** UCI Public Health

**WHY YOU MUST JOIN!**

We will be engaging our community to **practice antibiotic stewardship** to prevent **antibiotic resistance**.

Americans need to be educated on antibiotic resistance. **Antibiotic resistance** is projected to take 10 million lives annually by 2050. That's 1 individual every 3 seconds!  
**Antibiotic stewardship** is defined as correct antibiotic use and prescription.


A **major cause** is patient pressure for antibiotics. Only 54% of Americans know about the correct antibiotic for bacterial, not viral infections, according to Pew Research. Education is **urgent!** Join our Statewide Day of Action on Nov. 22nd (1-4 PM) to spread the word!

Share this knowledge with your family and friends, they can pledge with you!

Join us over Facebook!  
<https://fb.me/e/2A9yutHP>



Antibiotic Stewardship is Public Health (ASPH) Campaign



**OPEN OPPORTUNITY: Global Antibiotic Steward**



Rolling application!  
**UNTIL NOV. 18TH!**

Practice Public Health in action by educating your community about **antibiotic resistance**-- a potential future pandemic projected to take more lives than cancer by 2050.

- Only 1 in 2 Americans understand correct antibiotic use for bacterial, rather than viral infections (Pew Research, 2015).
- 45% of antibiotics are inappropriately or unnecessarily prescribed (Ray et al., 2019).

You are called to help educate the next health workers to prevent **antibiotic resistance**.

Sign up today by using the QR code or Using the link:  
<https://bit.ly/3ECeplx>

(Takes only 30 Seconds!)

Fig. 1. Paraphernalia for recruitment of Antibiotic Stewards included posters, banners, T-shirts, pins, all with a specifically produced logo.

## 5. Evaluation plan

The analysis and distillation of information published in the literature on the most challenging problems encountered in combatting antibiotic resistance, results of the international survey of knowledge, attitudes and practices, and questions received during group discussions were used to generate a set of best practices, or 'commandments' for antibiotic stewards:

1. A good antibiotic steward uses prescribed antibiotics for diagnosed bacterial infections.
2. A good antibiotic steward fully completes the prescribed dose of antibiotics.



3. A good antibiotic steward does not dispose of expired antibiotics in domestic waste bins or the environment.
4. A good antibiotic steward advocates the prudent use of antibiotics in farm animals only when they are sick.
5. A good antibiotic steward supports research to better understand and respond to antibiotic resistance.
6. A good antibiotic steward teaches students about the importance of antibiotics for global health security.
7. A good antibiotic steward tries to understand the One Health approach to combatting antibiotic resistance globally.
8. A good antibiotic steward advocates effective policies to stop the careless use and disposal of antibiotics.
9. A good antibiotic steward resists purchasing and eating food items laden with antibiotic residues.
10. A good antibiotic steward supports research to discover alternative therapies to prevent or treat infections.

We produced a video to capture the essence of these commandments (Fig. 2). As of November 2022, the video has been viewed 1600 times on LinkedIn, including comments and applause; and 62 times on YouTube. The acceptance of abstracts submitted to CUGH, ASPPH as oral presentations, and the acceptance of the manuscript by the peer-reviewed *One Health* journal<sup>14</sup> will continue to be used to disseminate the vision and mission of the ASPH initiative.

## Transdisciplinary Process

Antibiotic resistance and antibiotic stewardship are topics that cut across different and overlapping sectors of society and different academic and professional disciplines. In the case of antibiotic stewards, several academic and professional disciplines must be engaged, including microbiologists, epidemiologists, environmental scientists and behavioural scientists. In addition, health professionals, including public health practitioners, nurses, medical doctors, pharmacists and nutritionists, need to integrate knowledge of antibiotic resistance into their training curriculum and continuing professional development. In the government sector, ministries of health, environment, agriculture, and food and drug administrations need to be engaged in a collaborative systems-thinking approach. And in society at large, communities of farmers, patients, consumer groups and activists must be meaningfully engaged to enable desired outcomes in behaviour change to improve antibiotic stewardship. The transdisciplinary approach is necessary to change current practices across societal sectors including agriculture and food production, hospitals and community healthcare, and environmental management systems.

Therefore, we found that the One Health framework is particularly well suited to explore transdisciplinary pathways to stimulate community engagement through activation of knowledgeable antibiotic stewards.<sup>15</sup> Knowledge in this context is neither static nor unidirectional. As they embark on advocating best practices, good antibiotic stewards must also be receptive to new knowledge gained from engagement with various stakeholders in various communities. For example, an excursion with prospective antibiotic stewards to a local grocery store with an integrated pharmacy dispensary booth provides opportunities to discuss the use of antibiotics in agriculture and food production (Fig. 3-A) as well as strategies and programmes to prevent the disposal of expired antibiotics into sewage systems, which may end up contaminating the environment (Fig. 3-B). During a second visit to the adjoining pharmacy kiosk, it was observed that the receptacle for expired drugs was full, and the pharmacy no longer accepted antibiotics meant for disposal. This observation, potentially, meant that members of the public visiting that store for the purpose of discarding antibiotics either must drive to another location or, in some cases, improperly dispose of their medication. Further investigation of the medication disposal programme revealed that in California the Drug Take-Back Program was a temporary pilot with only sufficient state funding until early 2022, and the programme placed just 250 Med Bins in selected locations across the state and was no longer accepting new applications (Fig. 3-C). This gap in coverage provided an opportunity for antibiotic stewards to acquire new skills such as policy brief writing and advocacy coalition, and to add another layer of community engagement to improve antibiotic stewardship throughout the state. The first responsibility is to write to legislators to approve extended funding for sustaining the programme under revised Senate Bill 212 (Solid waste: pharmaceutical and sharps waste stewardship).<sup>16</sup> The second responsibility is to write to all pharmacy stores co-located in grocery stores throughout the state to apply for hosting a Med-Bin.<sup>17</sup> Published experiences in other countries suggests that such advocacy for pharmaceutical disposal

# *The Ten Commandments of Antibiotic Stewards*



The Ten Commandments of Antibiotic Stewards 2022



**Fig. 2.** YouTube video of the ten commandments of antibiotic stewards (<https://youtu.be/1100Mq0tllg>) (Panel A); and LinkedIn posting showing the number of impressions and prompt for targeting categories of viewers for through the “view analytics” application (Panel B).

programmes is necessary to address through a specific survey of knowledge, attitudes and practices of waste disposal, simultaneously with legislative advocacy.<sup>18,19</sup>

Food services also provided opportunities for community engagement in antibiotic stewardship. Prior to the implementation of this case study, food services have been targets of advocacy regarding the ethical treatment of farm animals, including, for example, free-range chickens and appropriate sizes for pig pens. For example, effective from January 2022, California voters approved the Farm Animal Confinement Initiative (Proposition 12), which requires that animals held in buildings, including hens kept for laying eggs, breeding sows and veal calves, are ‘housed in confinement systems that comply with specific standards for freedom of movement, cage-free design, and minimum floor space.’<sup>20</sup> In the context of this case study, it is noteworthy that California became the first state in the US to ban the use of antibiotics in livestock production.<sup>21</sup> However, there are gaps in the implementation of the law, and as recently as August 2022, a group of consumers sued the grocery retailer Whole Foods Market with the claim that traces of antibiotics were discovered in beef products that were labelled antibiotic-free.<sup>22</sup> The ongoing tension between

consumers, food producers and legislators provides an opportunity for antibiotic stewards to engage with communities and stakeholders regarding improving knowledge, beliefs, attitudes and practices regarding antibiotic residues in foods.

Finally, an excursion to the local coastal beach provides an opportunity for discussion of community acquired infections that may be resistant to antibiotics (Fig. 4-A) and the mixed-use places such as estuarine watersheds, which may lead to spillover of antibiotic-resistant pathogens from animals to humans and spillback from humans to animals (Fig. 4-B). In this context, the Ten Commandments of antibiotic stewards provide the template to stimulate discussion, and each one of the commandments may be emphasized or highlighted depending on the community engagement activity and target audience.



Fig. 3. Examples of grocery store encounter of opportunities for public engagement on antibiotic resistance and antibiotic stewardship regarding food production (Panel-A), and proper disposal of expired antibiotics (Panel-B); and inadequacy of funds to sustain the medication disposal program stimulates a new responsibility for Antibiotic Stewards (Panels-C and D). See: <https://www.takebackdrugs.org>.

# California Drug Take-Back Program

## Important Update for Existing Program Med Bin Hosts

The California Drug Take-Back Program has enough remaining funding to provide you with free liners (including shipping and disposal of filled liners) through early 2022. We encourage you to continue accepting unwanted medications in the med bins we've installed at your facility, shipping them back once they are no more than 2/3 full, and ordering replacement liners as you've previously done (using the process documentation provided to you upon installation of the med bin). SB 212 is expected to be fully operational, barring no delays, in 2022.



## We are no longer accepting applications for bin host locations.

This program was funded by California Department of Health Care Services' MAT Expansion Project and developed and administered in partnership with the [California Product Stewardship Council](#). The program's goal is to increase the disposal of unwanted medicines across the state of California. Safe medicine disposal bins (bins) were placed throughout the state for the express purpose of disposing unwanted medicines.

Nearly 250 bins were placed as part of this program, greatly expanding the network of bins across the state of California and providing all citizens with even greater access to free safe medicine disposal.

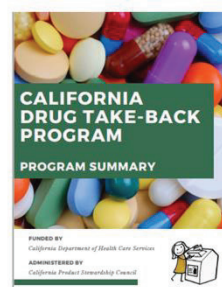


Fig. 3. Continued.

To recruit and train antibiotic stewards who are knowledgeable about the transdisciplinary framework of One Health, and to empower them, it is important to begin with subject-matter experts who can inspire and motivate stewards to act in response to opportunities for interventions existing in human health, animal healthcare, agriculture and environmental management. Therefore, the process begins with recruiting a multidisciplinary team as represented in this case study. It is often necessary to supplement the available expertise through a curated review of published literature on the various perspectives on the emergence and spread of antibiotic resistance. In addition, potential antibiotic stewards also represent various academic and professional backgrounds. Therefore, creating an opportunity for them to share their backgrounds, experiences and motivations in a focus group discussion can enrich the transdisciplinary process. In some cases, antibiotic stewards are motivated by personal or family members' experiences of infections that proved difficult to cure. Others are motivated by ethical considerations regarding farm animals or about environmental water quality. These experiences can also be tapped to enrich the knowledge of other stewards during discussion sessions. Finally, setting up an internet forum that is not only for disseminating information but also for receiving information from the larger community is a way to build a community of practice for sustained engagement around the topic of antibiotic resistance and best practices of antibiotic stewards.

## Project Impact

The ASPH project recruited antibiotic stewards and created educational programmes and advocacy tools to bridge translational science gaps in knowledge and infrastructure designed to reduce the burden of antibiotic-resistant infections. The project advanced calibration of a wide range of public knowledge, attitudes and practices internationally, and within various population and occupational constituencies, towards empowering antibiotic stewards and their potential effectiveness. The project's impact is consistent with the need to improve implementation of the global action plan (GAP) on antimicrobial resistance in many regions, particularly Africa, and with strategies to address urgencies expressed by the Global Leaders Group on antimicrobial resistance.<sup>23</sup> In addition to the Ten Commandments of antibiotic stewards, the GAP identified pillars around which stewards recruited through the ASPH project will continue to advocate and disseminate the Ten Commandments as starting points for public education and to



**Fig. 4.** Field excursions to a public beach or estuary provides an opportunity for antibiotic stewards to engage in discussions about environmental context of antibiotic resistance in terms of shared water environments with a crowd of individuals (Panel-A) and the possibility of spill-over or spill-back events with animals (Panel-B).

influence progress on regional, national and global action plans. These steps are necessary to integrate responses and interventions to reduce the global burden of antibiotic resistance through targeted actions in governance, oversight surveillance, data availability, research and development, and public education. To secure sustainable impact, it is necessary to cultivate a pipeline of new antibiotic stewards who will be initiated and primed with education about the topic and assessment of their baseline knowledge, beliefs, attitudes and practices. For example, in the autumn of 2022, at the university, we initiated a new cohort of prospective antibiotic stewards during orientation for new stewards. Everyone received a designated t-shirt, free of charge, and a pledge to remain engaged with the team of established stewards.

## Project Outlook

The ASPH project planted a seed in recruiting an inaugural cohort of antibiotic stewards. Through the impact of their work in education, advocacy and practice, the expectation is that similar international collaborative projects will be cloned and spread to other parts of the world to the extent that a global cadre of antibiotic stewards is found in every community. The current effort focused on college-educated stewards.

Additional work is needed to tailor the training and advocacy programme to different levels of education and to engage stakeholders who share information about antibiotics with the general population. These stakeholders include physicians, pharmacists, nurses, farmers, aquaculturists, and waste management and environmental system inspectors. Research is also needed to begin mapping the influence of antibiotic stewards using network analysis and to monitor improvements in knowledge, attitudes and practices through periodic international surveys. Given the broad range of communities and stakeholders needing education and information about antibiotics, and the rapidly changing landscape of legislation, litigation and advocacy, it is expected that antibiotic stewards will specialize in specific commandments, depending on their education and interests. For example, a cohort of stewards might focus on advocating for expansion of training programmes for the collection of expired antibiotics and work more closely with pharmacists and patients. Another cohort might specialize in antibiotic residues in food products and work more closely with advocacy groups, monitor ongoing litigation and work with grocery store owners, farmers and healthy-food enthusiasts in the community. A third group might focus on ecosystem health, including working with the sanitation districts to increase opportunities for monitoring antibiotic residues in water systems that may endanger wildlife. To this end, we plan to implement, annually, population surveys of knowledge, attitudes and practices; conduct literature reviews to identify international trends; and tailor the ASPH programme to accommodate emerging topics and promote life-long engagement of antibiotic stewards.

## Conclusions

The Ten Commandments of antibiotic stewards provide an opportunity to disseminate best practices regarding appropriate use of antibiotics to the general population according to a transdisciplinary One Health framework. Each of the commandments may represent the main topic of discussion during a focus group of antibiotic stewards, and the full set of commandments may be used as a curriculum for a continuing education course on antibiotic resistance. Some of the commandments may overlap in discussing certain topics and situations, and there are contemporary examples which may highlight priorities. For example, the proper disposal of antibiotics overlaps with ensuring that prescribed doses of antibiotics are completed through encouraging compliance, otherwise there would be no reason to discard excess antibiotics except in the cases of patient mortality or change in medication. The full impact of ASPH will be realized as the process of recruiting antibiotic stewards is replicated internationally, and a global community of stewards builds a community of practice with opportunity to engage the public and decision makers.

## Group Discussion Questions

1. Describe why addressing the adverse impacts of the emergence and spread of antibiotic resistance requires a One Health approach.
2. Describe the Ten Commandments of antibiotic stewards, and for each commandment, provide an example of how it is relevant in your own experience and community.
3. Explain why antibiotics are irrelevant for addressing pandemic infections such as COVID-19 or outbreaks such as the monkeypox of 2022. Note that the World Health Organization has called for suggestions to rename monkeypox to avoid stigmatization of species, places or peoples.

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