Research Article

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Evaluation of Knowledge Regarding the Use of Antibiotics among Pharmacy Undergraduates in Japan

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Antimicrobial resistance (AMR) is a global threat to human health. Education on antibiotics is essential for AMR prevention, and training should be provided for undergraduate pharmacy students. This study evaluated the knowledge regarding antibiotic use and AMR among fourth-year Japanese pharmacy students and the effect of a lecture on treating infectious diseases with antibiotics had on their knowledge. A questionnaire survey was conducted, and the responses were recorded before and after participants attended the lecture. A small subset of the prelecture survey questions was used for the postlecture survey. From a total of 540 participants, 330 and 234 responses were collected before and after the lecture, respectively. In the prelecture survey, 39.4% of the participants incorrectly answered that antibiotics can effectively treat the common cold, 13.3% had taken leftover antibiotics, and 17.3% had taken antibiotics prescribed for their family members or others. Furthermore, the prelecture survey data showed that the mean number (± standard deviation) of correct answers across the eight questions on treatment and diagnosis of infectious diseases and antibiotics was 2.21 ± 1.64. However, in the postsurvey, this figure increased to 5.00 ± 1.82. Although the lecture improved their knowledge to some extent, the results suggested that fourth-year pharmacy students have inaccurate knowledge regarding the appropriate use of antibiotics and AMR. Therefore, it is necessary to improve early-year undergraduate pharmacy education on antibiotics in Japan.

KEYWORDS antibiotics, Japanese pharmacy student, antimicrobial resistance, pharmacy education

INTRODUCTION

Antimicrobial resistance (AMR) has become a serious threat to human health globally. The reduction of unnecessary and inappropriate use of antibiotics is the most important preventative measure for AMR (1). The government of Japan established the National Action Plan on AMR in 2015 to reduce antibiotic use by two-thirds of the 2013 usage rate by the year 2020 (2). Although the usage of antibiotics in Japan decreased by 29.9% in 2020 compared to 2013, the targeted reduction could not be achieved, making it necessary to continue implementing preventative measures for AMR (3). Therefore, comprehensive measures are needed to reduce the inappropriate use of antibiotics, including promoting public awareness by providing education for both the general public and medical professionals.

Pharmacists educated on the treatment of infectious diseases are core members of the antimicrobial stewardship (AS) program (4). Promoting the appropriate use of antibiotics can reduce AMR (5–7), and pharmacists can play an important role in AS education for other medical professionals (8). Education on the proper use of antibiotics is an essential part of the AS program. Some studies have reported that AS education for pharmacy students effectively reduces AMR (9, 10). Although some elements necessary for AS are included in undergraduate education for pharmacy and other medical students, they are not exhaustive (6, 7). Additionally, because increasing personal knowledge influences attitudes and perceptions toward practices, the World Health Organization Global Action Plan on AMR has proposed population-based knowledge, attitude, and practice surveys as part of the monitoring and evaluation framework (1). To date, some studies have conducted surveys of the knowledge, attitudes, perceptions, and practices of pharmacy students related to AMR and AS (10–12). However, there are no such reports among undergraduate pharmacy students in Japan.

To the best of our knowledge, this study is the first to

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examine the AMR knowledge of Japanese pharmacy students. The purpose of this study was to compare fourth-year Japanese pharmacy students' knowledge of the appropriate use of antibiotics and AMR with that of the general public and to examine the effect of a single lecture on basic knowledge related to proper antibiotic use and infectious disease treatment.

METHODS

Curriculum

In Japan, 6 years of undergraduate education is necessary to obtain a pharmacist's license from the Faculty of Pharmaceutical Sciences; a postgraduate education is not a requirement. According to the model core curriculum of pharmaceutical education in Japan, first- to fourth-year pharmacy students acquire knowledge of the fundamental pharmaceutical sciences, including biology, chemistry, microbiology, pathophysiology, and pharmacokinetics/pharmacodynamics (PK/PD) (13). For example, at the Hoshi University School of Pharmacy and Pharmaceutical Sciences, chemistry and biology are taught in the first year, pharmacology of antibiotics and antimicrobial resistance are taught in the microbiology module in the second year, and PK/PD and diagnosis and treatment of infectious diseases are taught in the third year. Additionally, students learn about the ethics and culture expected of pharmacists as health care professionals. Fourth-year pharmacy students acquire skills and knowledge pertaining to pharmaceutical care during their preclinical training; this also forms their attitudes toward pharmaceutical care. After passing both objective structured clinical examinations and a computer-based test of their knowledge, attitudes, and practices, fifth-year pharmacy students participate in a 22-week-long clinical practice at a hospital and compounding pharmacy.

Study design and participants

This study was a cross-sectional, web-based anonymous questionnaire survey designed to evaluate the knowledge, attitudes, and perceptions of undergraduate pharmacy students regarding the use of antibiotics. This survey was conducted with fourth-year pharmacy students at Hoshi University School of Pharmacy and Pharmaceutical Sciences from 23 September 2020 to 2 October 2020 and from 24 September 2021 to 8 October 2021. To prevent the spread of coronavirus disease 2019 (COVID-19), fourth-year pharmacy students at the university attended on-demand lectures on the diagnosis and treatment of infectious diseases in their own time during the survey period in preclinical training. Table 1 shows the details of the lecture. Before the students attended the lecture, they participated in the prelecture survey after they received explanations of the purpose of the survey and how to access the prelecture survey questionnaire. The participants further responded to the postsurvey questionnaire immediately after the on-demand lecture.

TABLE 1
Outline of the on-demand lecture[a]

Course outline
Learning objectives
Can evaluate the need for antibiotics in clinical cases.
Can recommend appropriate antibiotics prescription in clinical cases.
Introduction
AMR and AS programs
Case study 1: Catheter-related blood stream infection with *Staphylococcus aureus*
Necessity of antibiotics
Detection of pathogens and antibiotic susceptibility
Empiric therapy and definitive therapy
Appropriate dose and interval of administration of antibiotics
Duration of treatment of antibiotics
Case study 2: Common cold in children
Manual of Antimicrobial Stewardship in Japan
Appropriate use of oral antibiotics
Adverse events of oral antibiotics
National Action Plan on AMR in Japan
Conclusion

[a]Instructor was a pharmacist. Lecture length was 60 min. In the lecture, the instructor addressed the topics related to all questions of the questionnaire. Students could attend this lecture on their own time during the term of preclinical training.

Ethics statement

When participants accessed the website to respond to the questionnaires, the policy for using the collected data and the protection of personal information were presented. Only those who agreed to provide informed consent were allowed to respond to the questionnaire. The study protocol was approved by the Institutional Review Board of Hoshi University (2020-02).

Questionnaire

A web-based anonymous questionnaire was administered to the students before (prelecture survey) and/or after (postlecture survey) an on-demand lecture. The prelecture survey questions were composed with the reference of the Antibiotics Awareness Survey 2018, which was conducted on the general public (14). A small subset of the prelecture survey questionnaire was used as the postlecture survey questions. Table 2 shows the details of the survey items.

Statistics

Data were collected using the Questant software, an online questionnaire program (Macromill, Tokyo, Japan). Simple tabulation

TABLE 2
Survey items

Question	Answer options	Timing[a]	
		Pre	Post
Q1: Do you know what kind of diseases antibiotics are effective against? Please select all applicable answers.	Common cold	•	
	Influenza virus		
	Norovirus		
	Cystitis		
	Pneumonia		
	Otitis media		
	Diarrhea		
	Do not know		
	Others		
Q2: What kind of medicine would you like to receive when seeing a doctor for the common cold? Please select all applicable answers.	Antitussive	•	
	Antipyretic		
	The medicine that suppresses runny nose		
	Antibiotics		
	Expectorant		
	Analgesic		
	Troche		
	Gargle		
	Stomach medicine		
	Others		
	Nothing applies		
Q3: Do you take the full dose of antibiotics prescribed?	Take up all they prescribed	•	
	Stop taking them when the condition is healed		
	Forget to take them and have not taken up all		
	Do not take them as much as possible from the beginning		
Q4: How do you manage leftover antibiotics? Please select all applicable answers.	Keeping them for use when needed	•	
	Take them when falling ill		
	Giving them to others		
	Throwing them away		
	Consult the pharmacy and throw them away		
	Others		
Q5: Have you ever taken antibiotics obtained from your family or others?	Yes	•	
	No		
Q6: What do you think about taking antibiotics obtained from your family or others?	Try not to take them	•	
	Worried because I have not seen a doctor, but take them		
	Convenient because I do not have to go to the clinic		
	No problem if the symptoms are the same as before		
	Others		
Q7: Do you know about antimicrobial resistance?	I know	•	
	I have only heard (but do not know)		
	I do not know		

(Continued on next page)

TABLE 2 (Continued)

Question	Answer options	Timing[a]	
		Pre	Post
Q8: Answer the following statements regarding treatment and diagnosis of infectious disease			
C-reactive protein is a specific marker for bacterial infection.	True / False / Do not know		
Fever is a specific marker for bacterial infection.	True / False / Do not know		
Blood culture after antibiotic administration is useful for identifying the pathogen of infectious disease.	True / False / Do not know	•	•
Clinical breakpoint is the minimum concentration of antibiotics that can inhibit the growth of bacteria.	True / False / Do not know		
Gram-positive cocci are stained by Gram stain.	True / False / Do not know		
Broth microdilution method is one of the quantitative susceptibility methods.	True / False / Do not know		
Q9: Which pathological conditions do you think the treatment using antibiotics is recommended for? Please select all applicable answers.	Common cold in adults		
	Viral pharyngitis in children		
	Mild acute nasal sinusitis in children	•	•
	Acute bronchitis in adults without underlying health conditions, such as chronic respiratory diseases		
	Nothing applies		
Q10: Which antibiotics are recommended for administration in a single dose but not for a divided dose when the daily dose is the same?	Levofloxacin (new quinolone)		
	Ampicillin (penicillin)		
	Meropenem (carbapenem)		
	Cefazolin (first-generation cephalosporin)	•	•
	Gentamicin (aminoglycoside)		
	Nothing applies		

[a]Some questions were asked prelecture and also postlecture.

was performed using SPSS version 26.0 (IBM, Armonk, NY, USA). In the prelecture and postlecture comparisons, an unpaired *t* test was performed to compare the average number of correct answers across the eight questions. Statistical significance was set at a *P* level of <0.05.

RESULTS

The response rates for the questionnaire were 61.1% (330/540 pharmacy students) and 43.3% (234/540 pharmacy students) before and after attending an on-demand lecture, respectively. Furthermore, it was confirmed that all pharmacy students, including the respondents, viewed the entire lecture.

Table 3 shows the prelecture survey responses to the questions regarding antibiotics and medicines administered for selected infectious diseases, including the common cold. The prelecture survey showed that some respondents incorrectly considered the effectiveness of antibiotics against the common cold (39.4%) and influenza (30.9%). Moreover, 15.8% of the respondents in the prelecture survey wanted to take antibiotics against the common cold. Table 4 shows the prelecture survey responses to questions regarding antibiotic medication adherence and AMR. The prelecture survey showed that the majority of the respondents (69.7%) had used antibiotics according to the instructions of the prescriber. However, the ratio of the respondents who did not finish the prescribed antibiotic courses because of recovery from symptoms was 20.9% in the prelecture survey. In addition, 30.3% of the

TABLE 3
Perceptions of pharmacy students regarding antibiotics and various infectious diseases before taking the on-demand lecture

Question and perception	Response rate (%)	
	Prelecture	AAS 2018
Question 1: Effectiveness of antibiotics[a]		
Common cold	130 (39.4)	339 (49.9)
Influenza virus	102 (30.9)	334 (49.2)
Norovirus	104 (31.5)	158 (23.3)
Cystitis	139 (42.1)	181 (26.7)
Pneumonia	197 (59.7)	175 (25.8)
Otitis media	137 (41.5)	136 (20.0)
Diarrhea	77 (23.3)	64 (9.4)
Do not know	5 (1.5)	
Others	16 (4.8)	25 (3.7)
Question 2: Expectation on prescribing for the common cold		
Antitussive	257 (77.9)	446 (61.9)
Antipyretic	236 (71.5)	431 (59.8)
The medicine that suppresses runny nose	227 (68.8)	382 (53.0)
Antibiotics	52 (15.8)	217 (30.1)
Expectorant	197 (59.7)	210 (29.1)
Analgesic	72 (21.8)	130 (18.0)
Troche	101 (30.6)	99 (13.7)
Gargle	56 (17.0)	98 (13.6)
Stomach medicine	20 (6.1)	69 (9.6)
Others	4 (1.2)	18 (2.5)
Nothing applies	5 (1.5)	

[a]For Question 1, prelecture $n = 330$, AAS 2018 $n = 679$; for Question 2, lecture $n = 330$; for AAS 2018 (the Antibiotics Awareness Survey 2018 [14]), $n = 721$.

respondents kept antibiotics for later use, and 13.3% reported taking leftover antibiotics when they experienced other ailments. The current results showed that 17.3% of the respondents reported taking antibiotics prescribed to members of their families or others. Moreover, 17.8% of the respondents considered it unproblematic to take antibiotics prescribed to others. Although 85.5% of the respondents were knowledgeable about AMR, 13.3% had only heard of the term. Tables 3 and 4 summarize the results of our comparison of fourth-year Japanese pharmacy students with the general public in terms of responses to the Antibiotics Awareness Survey 2018 (14).

Table 5 shows a comparison of results of the prelecture and postlecture surveys. The mean number of correct responses across the eight questions in the postlecture survey (i.e., Question 8, statements 1 to 6, and Questions 9 and 10) was 2.21 ± 1.64 for the prelecture survey. However, the postlecture survey data showed that the mean number of correct answers significantly increased to 5.00, with a standard deviation of 1.82 ($P < 0.001$). In the postlecture survey, although the correct answer rates for each statement of Question 8 increased, the correct answer rate for the timing of blood culture was the lowest, at 44%. Regarding pathological conditions that generally do not require treatment with antibiotics (Question 9), the percentage of respondents who correctly answered "nothing applies" was 14.2% in the prelecture survey, which increased to 56.8% in the postlecture survey. In answering the question on the dosage administration of various antibiotics (Question 10), only 4.2% of respondents answered correctly in the prelecture survey. However, correct responses increased to 23.1% in the postlecture survey.

DISCUSSION

In the present study, we examined the knowledge of antibiotic use and AMR among fourth-year Japanese undergraduate students and the effect of a lecture on their knowledge, using a questionnaire. In the prelecture survey, 39.4% of the respondents considered that antibiotics were effective against the common cold. Moreover, 13.3% of the respondents had taken leftover antibiotics, and 17.3% of the respondents had taken antibiotics prescribed for their family members or others. Furthermore, the mean number of correct answers across the eight questions on infectious treatment and antibiotics increased in the postlecture survey compared to the

TABLE 4
Knowledge of pharmacy students regarding prescribed and nonprescribed antibiotics before taking the on-demand lecture

Knowledge area	Response rate (%)	
	Prelecture (*n* = 330)	AAS 2018[a] (*n* = 679)
Taking the full dose of antibiotics (Question 3)		
Take the full dose as prescribed	230 (69.7)	356 (52.4)
Stop taking when condition is healed	69 (20.9)	231 (34.0)
Forget to take full course	13 (3.9)	39 (5.7)
Do not take them as much as possible from the beginning	13 (3.9)	53 (7.8)
Unanswered	5 (1.5)	
Making do with leftover antibiotics (Question 4)		
Keep for later use	100 (30.3)	201 (29.6)
Take when falling ill	44 (13.3)	147 (21.6)
Give to others	3 (0.9)	18 (2.7)
Throw away	134 (40.6)	303 (44.6)
Consult pharmacy and throw away	15 (4.5)	36 (5.7)
Other	29 (8.8)	
Taking antibiotics prescribed for your family or others (Question 5)		
Yes	57 (17.3)	144 (21.1)
No	269 (81.5)	535 (78.8)
Unanswered	4 (1.2)	4 (1.2)
Think about taking antibiotics prescribed for your family or others (Question 6)		
Try not to take them	259 (78.5)	403 (59.4)
Worried because I have not seen doctor, but take them	34 (10.3)	115 (16.9)
Convenient because I do not have to go to clinic	9 (2.7)	67 (9.9)
No problem if symptoms are same as before	16 (4.8)	121 (17.8)
Others	7 (2.1)	9 (1.3)
Unanswered	5 (1.5)	
Knowledge of AMR (Question 7)		
I know	282 (85.5)	
I have heard of it but do not have good knowledge	44 (13.3)	
I do not know	1 (0.3)	
Unanswered	3 (0.9)	

[a]AAS 2018 is the Antibiotics Awareness Survey 2018 (14).

prelecture survey. Although the lecture improved their knowledge to some extent, the results suggested that fourth-year pharmacy students have inaccurate knowledge related to the appropriate use of antibiotics and AMR.

Overprescription of antibiotics can lead to the development and progression of AMR (15). Several surveys of the general public's knowledge and attitudes regarding antibiotics have been conducted in Japan and abroad; in the Antibiotics Awareness Survey 2018 and 2020, 49.9% and 34.3% of the respondents, respectively, stated that antibiotics were effective against the common cold, indicating that the general public's knowledge regarding antibiotics and the common cold had improved since 2018 (14, 16). Furthermore, in other surveys of the general public, approximately 40% of the respondents also considered antibiotics to be effective against the common cold (17–20). Moreover, although fourth-year Japanese pharmacy students have been learning the basics of antibiotics and microbiology, their awareness in the present study was almost the same as that of the general public (16–20). Moreover, 39.7% and 34.6% of the respondents answered that they stopped taking antibiotics contrary to their physician's instructions in the Antibiotics Awareness Surveys of 2018 and 2020, respectively (14, 16). On the contrary, the Nippon AMR One Health Report (NAOR) 2019 revealed that the percentage of the general public who had stopped taking antibiotics or adjusted a dose based on their own judgment was 23.6% (2017) and 24.0% (2018) (18). Although the results of these surveys are varied, medication adherence for antibiotics among pharmacy students is considered

TABLE 5
Knowledge of pharmacy students regarding treatment and diagnosis of infectious diseases and antibiotics both before and after taking the on-demand lecture (Questions 8 to 10)[a]

Question and answer	Rate (%) of correct responses	
	Prelecture (n = 330)	Postlecture (n = 234)
Question 8: Statements regarding treatment and diagnosis of infectious disease		
C-reactive protein is a specific marker for bacterial infection. (False)	91 (27.6)	172 (73.5)
Fever is a specific marker for bacterial infection. (False)	149 (45.2)	150 (64.1)
Blood culture after antibiotic administration is useful for identifying the pathogen of infection disease. (False)	86 (26.1)	103 (44.0)
Clinical breakpoint is the minimum concentration of antibiotic that is able to inhibit the growth of bacteria. (False)	70 (21.2)	172 (73.5)
Gram positive cocci are stained red by Gram stain. (False)	164 (49.7)	189 (80.8)
Broth microdilution method is one of the quantitative susceptibility methods. (True)	93 (28.2)	198 (84.6)
Question 9: Pathological conditions where treatment using antibiotics is recommended		
Common cold in adults (False)	93 (28.2)	17 (7.3)
Viral pharyngitis in children (False)	146 (44.2)	23 (9.8)
Mild acute nasal sinusitis in children (False)	110 (33.3)	37 (15.8)
Acute bronchitis in adults without underlying health conditions such as chronic respiratory diseases (False)	137 (41.5)	69 (29.5)
Nothing applies (True)	47 (14.2)	133 (56.8)
Question 10: Antibiotics where administration in a single dose is recommended		
Levofloxacin (True)	121 (36.7)	139 (59.4)
Ampicillin (False)	98 (29.7)	24 (10.3)
Meropenem (False)	47 (14.2)	13 (5.6)
Cefazolin (False)	65 (19.7)	46 (19.7)
Gentamicin (True)	78 (23.6)	90 (38.5)
Nothing applies (False)	26 (7.9)	11 (4.7)
Completely correct answers (all 6)	14 (4.2)	54 (23.1)

[a]Overall, the mean (± SD) number of correct answers, per person, for Questions 8 to 10 was 2.21 ± 1.642 before the lecture and 5.00 ± 1.821 after the lecture. This increase was significant (P < 0.001, unpaired t test).

to be better or similar to that of the general public. In addition, the NAOR 2019 reported that the percentage of respondents who kept leftover antibiotics was 11.7% (2017) and 11.9% (2018) (18). Meanwhile, the percentage of respondents who kept leftover antibiotics was 29.6% and 31.6% in the Antibiotics Awareness Surveys of 2018 and 2020, respectively (14, 16). Therefore, the proportion of pharmacy student respondents who kept leftover antibiotics in the present study was the same or higher than that of the general public. Furthermore, approximately 20% of the respondents reported taking leftover antibiotics prescribed to them or others in both the present study and the

Antibiotics Awareness Survey 2018 (14). Although more than 80% of the respondents knew about AMR, these results indicated the possibility that there are as many students as the general public who cannot appropriately manage antibiotics for the suppression of AMR. The poor results in the prelecture survey may reflect the common knowledge and basic attitudes of early-year pharmacy students. Considering that acquiring sufficient knowledge and forming appropriate attitudes lead to desirable behaviors (21), modifying the basic education on AMR for early-year pharmacy students may be necessary.

From the results of the prelecture survey in this study, although fourth-year pharmacy students have been learning fundamental pharmaceutical sciences such as microbiology and pathophysiology, it is possible that their knowledge related to AS is underestablished. In addition, the principles of AS educational content may not be fully covered in the educational program. Therefore, it is necessary to review the curriculum so that the principles needed for the proper use of antibiotics are covered. Moreover, although a single on-demand lecture improved the correct answer rate of each question related to infectious disease treatment and the use of antibiotics, only 25% of the respondents understood the dose used for various antibiotics after taking the lecture. Furthermore, less than half of the respondents correctly answered the question on the timing of blood culture, even after attending the lecture. These results suggest that the present lecture alone may not have improved their knowledge, including PK/PD and identifying the pathogen. Therefore, it is also necessary to improve the educational program, including our present lecture, in preclinical training. In addition, the present study only evaluated the short-term effects of a single lecture and could not examine the long-term effects. Considering the inadequate knowledge of AS from the results of the prelecture survey, a long-term effect of the lecture may not be expected. In addition, passive educational programs, including lectures, are important for acquiring knowledge of AS. However, these may not be enough (7). Various educational programs based on an active learning approach have been used to teach the topics of AS (22). For example, the AS elective course, which mainly consists of preclass assignments and in-class group work, has been shown to improve students' awareness and familiarity with the principles of AS and increase their confidence in participating in the AS program (23). Although the active learning theory was not considered in the present study, active learning programs are expected to be useful for pharmacy AS education. It is necessary to introduce an active educational program based on the clinical utilization of AS principles using training methods not only during the preclinical training but also during the first 3 years of pharmacy education.

There are some limitations to the present study. First, since the survey was conducted at one institution, the results could be influenced by the educational curriculum of that university. Second, it is possible that the respondents had access to external resources, such as a web browser, when answering the questions; this may have influenced the results. Third, after undergoing the lecture, the respondents could answer the postlecture survey at any time during the survey period. Therefore, it is possible that some time elapsed between the lecture and the completion of the postlecture survey. Fourth, the survey was conducted for 1 year and before participants acquired pharmacy practice experience; therefore, we could not examine the differences in knowledge between the students in different years. In future studies, a comprehensive survey with larger sample sizes will be required to evaluate pharmacy students' knowledge of antibiotic use. Finally, because the questionnaires were anonymous, we could not confirm whether the respondents completed both the prelecture and postlecture surveys. In the future, a registered survey is needed to examine individual changes caused by AS education.

In conclusion, the present survey suggests that undergraduate Japanese pharmacy students, as well as the general public, have inaccurate knowledge related to the use of antibiotics. Although the lecture improved their knowledge in the present study, their poor knowledge of the fundamental pharmaceutical sciences related to AS and AMR remains a critical problem. Therefore, there is a need to revise undergraduate education to improve early-year pharmacy students' knowledge of AMR and AS.

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REFERENCES

1. World Health Organization. 2015. Global action plan on antimicrobial resistance. https://www.who.int/publications/i/item/9789241509763.
2. Government of Japan. 2016. National action plan on antimicrobial resistance 2016–2020. Tokyo, Japan. https://www.mhlw.go.jp/file/06-Seisakujouhou-10900000-Kenkoukyoku/0000138942.pdf.
3. Gu Y, Fujitomo Y, Ohmagari N. 2021. Outcomes and future prospect of Japan's National Action Plan on Antimicrobial Resistance (2016–2020). Antibiotics 10:1293. https://doi.org/10.3390/antibiotics10111293.
4. Centers for Disease Control and Prevention. 2019. Core elements of hospital antibiotic stewardship programs. CDC, Atlanta, GA. https://www.cdc.gov/antibiotic-use/core-elements/hospital.html.
5. Dellit TH, Owens RC, McGowan JE, Jr, Gerding DN, Weinstein RA, Burke JP, Huskins WC, Paterson DL, Fishman

NO, Carpenter CF, Brennan PJ, Billeter M, Hooton TM, Infectious Diseases Society of America, Society for Healthcare Epidemiology of America. 2007. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. Clin Infect Dis 44:159–177. https://doi.org/10.1086/510393.

6. Barlam TF, Cosgrove SE, Abbo LM, MacDougall C, Schuetz AN, Septimus EJ, Srinivasan A, Dellit TH, Falck-Ytter YT, Fishman NO, Hamilton CW, Jenkins TC, Lipsett PA, Malani PN, May LS, Moran GJ, Neuhauser MM, Newland JG, Ohl CA, Samore MH, Seo SK, Trivedi KK. 2016. Implementing an antibiotic stewardship program: Guidelines by the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America. Clin Infect Dis 62:e51–e77. https://doi.org/10.1093/cid/ciw118.
7. Japanese Society of Chemotherapy, Japanese Association for Infection Disease. 2017. Guidance for implementing an antimicrobial stewardship program in Japan. Yakugaku Zasshi 91:709–746. (In Japanese.) https://doi.org/10.11150/kansenshogakuzasshi.91.709.
8. Garau J, Bassetti M. 2018. Role of pharmacists in antimicrobial stewardship programmes. Int J Clin Pharm 40:948–952. https://doi.org/10.1007/s11096-018-0675-z.
9. Justo JA, Gauthier TP, Scheetz MH, Chahine EB, Bookstaver PB, Gallagher JC, Hermsen ED, DePestel DD, Ernst EJ, Jacobs DM, Esterly JS, Suda KJ, Olsen KM, Abbo LM, MacDougall C. 2014. Knowledge and attitudes of doctor of pharmacy students regarding the appropriate use of antimicrobials. Clin Infect Dis 59:S162–S169. https://doi.org/10.1093/cid/ciu537.
10. Sakeena MHF, Bennett AA, Jamshed S, Mohamed F, Herath DR, Gawarammana I, McLachlan AJ. 2018. Investigating knowledge regarding antibiotics and antimicrobial resistance among pharmacy students in Sri Lankan universities. BMC Infect Dis 18:209. https://doi.org/10.1186/s12879-018-3107-8.
11. Jairoun A, Hassan N, Ali A, Jairoun O, Shahwan M. 2019. Knowledge and attitudes of doctor of pharmacy students regarding the appropriate use of antimicrobials. BMC Public Health 19:518. https://doi.org/10.1186/s12889-019-6878-y.
12. Lubwama M, Onyuka J, Ayazika KT, Ssetaba LJ, Siboko J, Daniel O, Mushi MF. 2021. Knowledge, attitudes, and perceptions about antibiotic use and antimicrobial resistance among final year undergraduate medical and pharmacy students at three universities in East Africa. PLoS One 16:e0251301. https://doi.org/10.1371/journal.pone.0251301.
13. Pharmaceutical Society of Japan, Council for Fostering Human Resources in Pharmacy Education. 2018. Model core curriculum for pharmacy education. Pharmaceutical Society of Japan, Tokyo, Japan. https://www.pharm.or.jp/kyoiku/pdf/corecurri_eng180426.pdf.
14. AMR Clinical Reference Center, National Center for Global Health and Medicine. 2018. Antibiotics Awareness Survey 2018. National Center for Global Health and Medicine, Tokyo, Japan. (In Japanese.) https://amr.ncgm.go.jp/pdf/20181026_ig_vol8_report.pdf.
15. Japan Ministry of Health, Labour and Welfare. 2019. Manual of antimicrobial stewardship, 1st ed. https://www.mhlw.go.jp/file/06-Seisakujouhou-10900000-Kenkoukyoku/0000193504.pdf.
16. AMR Clinical Reference Center, National Center for Global Health and Medicine. 2020. Antibiotics Awareness Survey 2020. National Center for Global Health and Medicine, Tokyo, Japan. (In Japanese.) http://amr.ncgm.go.jp/pdf/20201006_report.pdf.
17. Mazińska B, Strużycka I, Hryniewicz W. 2017. Surveys of public knowledge and attitudes with regard to antibiotics in Poland: did the European Antibiotic Awareness Day campaigns change attitudes? PLoS One 12:e0172146. https://doi.org/10.1371/journal.pone.0172146.
18. AMR One Health Surveillance Committee. 2019. Nippon AMR one health report (NAOR) 2019. AMR One Health Surveillance Committee, Tokyo, Japan. https://www.mhlw.go.jp/content/10900000/000714628.pdf.
19. Kamata K, Tokuda Y, Gu Y, Ohmagari N, Yanagihara K. 2018. Public knowledge and perception about antimicrobials and antimicrobial resistance in Japan: a national questionnaire survey in 2017. PLoS One 13:e0207017. https://doi.org/10.1371/journal.pone.0207017.
20. Tsuzuki S, Fujitsuka N, Horiuchi K, Ijichi S, Gu Y, Fujitomo Y, Takahashi R, Ohmagari N. 2020. Factors associated with sufficient knowledge of antibiotics and antimicrobial resistance in the Japanese general population. Sci Rep 10:3502. https://doi.org/10.1038/s41598-020-60444-1.
21. Bettinghaus EP. 1986. Health promotion and the knowledge-attitude-behavior continuum. Prev Med 15:475–491. https://doi.org/10.1016/0091-7435(86)90025-3.
22. Nasr ZG, Abbara DM, Wilby KJ. 2021. A scoping review of antimicrobial stewardship teaching in pharmacy education curricula. Am J Pharm Educ 85:8415. https://doi.org/10.5688/ajpe8415.
23. Gauthier TP, Sherman EM, Unger NR. 2015. An elective course on antimicrobial stewardship. Am J Pharm Educ 79:157. https://doi.org/10.5688/ajpe7910157.