Original Article

Methods of Antibiotic Disposal by Laypeople and Various Types of Drug Distributors in Thailand

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Objective: To determine the methods that laypeople and various types of drug distributors use to dispose of leftover antibiotic and expired antibiotic in Thailand.

Materials and Methods: Questionnaires designed to elicit information about the methods used to dispose of leftover antibiotic and expired antibiotic were sent to the laypeople living in four communities of two provinces in Thailand, and to various types of drug distributors, including drug stores, private medical clinics, health promotion hospitals, and general hospitals located in all regions of Thailand. The returned questionnaires were analyzed using descriptive statistics.

Results: The majority of the 709 laypeople and some of the 182 drug stores, 76 private medical clinics, 34 general hospitals, and 69 health promotion hospitals that responded to the questionnaire said that they would dispose of leftover antibiotic and expired antibiotic as garbage, in the toilet, or into a sanitary sewer that drains into a public water source.

Conclusion: The methods that laypeople and various types of drug distributors use to dispose of leftover antibiotic and expired antibiotic are generally inappropriate, and these behaviors will result in contamination of the environment with antibiotics, which can induce the emergence of antibiotic resistance in bacteria living in the environment.

Keywords: Antibiotic disposal, laypeople, drug distributors, Thailand

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Antimicrobial resistance occurs when micro-organisms change after they are exposed to antimicrobial drugs. Selective antibiotic pressure is an important determinant of emergence and dissemination of antibiotic resistance[1]. As a result, antibiotic becomes ineffective and infection persists in the body with increasing risk of spread of the infection to others. Antibiotic is, therefore, considered the most important driver of antimicrobial resistance. Antimicrobial resistance to antibiotic is an increasing clinical problem worldwide and in Thailand, and it is causing a significant public health threat in terms of morbidity, mortality, and economic loss[2-6].

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The global action plans on antimicrobial resistance launched by the World Health Organization (WHO), the World Organisation for Animal Health (OIE), and the Food and Agriculture Organization of the United Nations (FAO) in 2015[7] state that antimicrobial resistance will affect sectors beyond human health, such as animal health, agriculture, food security, environment, and economic development. Therefore, whole-of-society engagement, including a One Health approach, must be adopted and implemented to combat antimicrobial resistance.

The environment is being increasingly recognized for its role in the global spread of clinically relevant antibiotic resistance[8]. One of the proposed critical knowledge gaps and research needs relating to the environmental dimensions of antimicrobial resistance is the contributions of different sources of antibiotics in the environment[9]. The environment usually contains antibiotic residues from humans, animals, and foods. Additionally, leftover and expired antibiotic are disposed by people and drug

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distributors in the environment. Antibiotic residues in the environment can induce resistance in the bacteria living in the environment, and these antibiotic-resistant bacteria can be transmitted to humans and animals resulting in colonization and infection with antibiotic-resistant bacteria. Therefore, the action plans to combat antimicrobial resistance must include the establishment and effective implementation of legislation or regulations to prevent contamination of the environment with antibiotic. Such legislation or regulations are often lacking in specifics or regulatory potency in part because the science and understanding needed to develop this type of policy is lacking. Therefore, this needs to be addressed. The WHO asked its member states to respond to a questionnaire relating to the status of in-country legislation or regulations to prevent contamination of the environment with antimicrobials and antibiotic-resistant bacteria in 2017. The responsible institute in Thailand responded that Thailand currently has no specific legislation relating to the control of wastewater discharges containing antimicrobials and antibiotic-resistant bacteria into the environment because the required relevant information are insufficient for establishing this type of legislation or regulations to prevent contamination of the environment with antimicrobials and antibiotic-resistant bacteria.

Accordingly, the objective of the present study was to determine the methods that laypeople and various types of drug distributors, including drug stores, private medical clinics, health promotion hospitals, and general hospitals, use to dispose of leftover and expired antibiotic in Thailand.

Materials and Methods

The present study was approved by the Institutional Review Board of the Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand.

Study population

The layperson population for the present study consisted of 1,000 adult laypeople living in four communities of two provinces located in the northern and eastern regions of Thailand that were the study sites of the Thailand Antimicrobial Resistance Containment and Prevention Program. The drug distributor population for the present study comprised of 1,017 drug distributors, including drug stores, private medical clinics, health promotion hospitals, and general hospitals, located in all five regions of Thailand. The included drug distributors were randomly selected, and their representation was estimated to be 5% to 15% of all drug stores, private medical clinics, health promotion hospitals, and general hospitals located in all five regions of Thailand.

Preparation of questionnaire on disposal of antibiotic

The core content of the questionnaire on disposal of antibiotic comprised questions designed to elicit the methods by which leftover and expired antibiotic are disposed of by laypeople and drug distributors. The questionnaire was written in Thai language. The questionnaire contained three types of elicitations, including a list of specific methods of antibiotic disposal from which the respondent could choose, an open-ended choice to describe other methods of antibiotic disposal, and a section for additional comments and suggestions. More than one choice of method of antibiotic disposal could be selected.

Distribution of questionnaire on disposal of antibiotic

The disposal of antibiotic questionnaire for laypeople was given to 500 randomly selected village health volunteers to distribute to two adult laypeople aged 18 years or older who were members of households under their oversight to voluntarily respond to the questionnaire. The questionnaire on disposal of antibiotic for drug distributors was mailed to selected drug stores, private medical clinics, health promotion hospitals, and general hospitals. A postage paid envelop was also included with the questionnaire so that the questionnaire could be returned to the research team conveniently and at no cost to the respondent.

Analysis of responses to questionnaire on disposal of antibiotic

The responses to the questionnaires received from laypeople and drug distributors were analyzed using descriptive statistics.

Results

Responses of laypeople to the questionnaire on disposal of antibiotic

Seven hundred and nine laypeople responded to the questionnaire. The mean age of respondents was 52.4 years with standard deviation of 13.2 years, and 62% of them were female. The responses to the questionnaire on disposal of leftover antibiotic from 709 laypeople are shown in Table 1. Most laypeople respondents disposed of their leftover antibiotic by throwing it away as garbage. Some of them reported

Table 1. Responses to questionnaire on disposal of leftover antibiotic from 709 laypeople

Method of disposal of leftover antibiotic	Number of respondents n (%)
Throw it away as garbage	396 (55.9)
Return it to hospital	162 (22.8)
Throw it away in toilet	109 (15.4)
Keep it to be used for future illness	108 (15.2)
Throw it in sanitary sewer draining into open public water source	54 (7.6)
Return it to drug store	38 (5.4)
Give it to others with similar illness	29 (4.1)

Table 2. Responses to questionnaire on disposal of expired antibiotic from 709 laypeople

Method of disposal of expired antibiotic	Number of respondents n (%)
Throw it away as garbage	395 (55.7)
Return it to hospital	154 (21.7)
Throw it away in toilet	102 (14.4)
Throw it insanitary sewer draining into open public water source	40 (5.6)
Return it to drug store	18 (2.5)
Keep it to be used for future illness	15 (2.1)
Give it to others with similar illness	15 (2.1)

Table 3. Number of mailed questionnaires to and returned questionnaires from the selected drug distributors

Type of drug distributor	Number of mailed questionnaires	Number of returned questionnaires n (%)
Drug stores	611	182 (29.8)
Private medical clinics	202	76 (37.6)
General hospitals	77	34 (44.2)
Health promotion hospitals	127	69 (54.3)
Total	1,017	361 (35.5)

returning it to the hospital, throwing it away in the toilet, or keeping it to treat a future illness. A few of them would give it to others with a similar illness, would throw it away in an open public water source, or would return it to a drug store. The responses to the questionnaire on disposal of expired antibiotic from 709 laypeople are shown in Table 2. The responses to the questionnaire on disposal of expired antibiotic were similar to the responses to the questionnaire on disposal of leftover antibiotic. Most respondents reported disposing of expired antibiotic by throwing it away as garbage.

Responses of drug distributors to the questionnaire on disposal of antibiotic

The number of questionnaires mailed to selected drug distributors and the number of questionnaires that were returned are shown in Table 3. The overall response rate from drug distributors was 35.5%.

Responses relating to the characteristics of drug stores, and the methods of disposal of expired antibiotic at 182 drug stores are shown in Table 4. Most of the drug stores that responded were single drug stores, and oral antibiotic was available in all of them. Only a few drug stores accepted the return of expired antibiotic from the purchaser. Although most drug stores reported returning expired antibiotic to the pharmaceutical manufacturer or distributor, many of them disposed of expired antibiotic as garbage, in the toilet, or by throwing it into an open public water source. Additional comments on disposal of expired antibiotic included having guidelines on appropriate disposal of expired antibiotic and availability of responsible department for disposal of expired antibiotic.

Responses relating to the characteristics of private medical clinics, and the methods of disposal of expired antibiotic at 76 private medical clinics are shown in Table 5. Antibiotic was available in almost all of the private medical clinics that responded. Most of them disposed of the expired antibiotic by themselves via garbage, toilet, or open public water source. Some of them returned it to the pharmaceutical manufacturer or distributor, or they sent it to be disposed of at a responsible public department or official drug destruction source. Additional comments on disposal of expired antibiotic included having guidelines on appropriate disposal of expired antibiotic, availability of responsible department for disposal of expired antibiotic, and antibiotic should be returned to pharmaceutical manufacturer or distributor before its expiration date.

Responses relating to the characteristics of general hospitals, and methods of disposal of leftover antibiotic and expired antibiotic at 34 general hospitals are shown in Table 6. All of them had antibiotic. Most of them had guidelines on appropriate disposal of leftover antibiotic and expired antibiotic. Most hospitals sent leftover antibiotic and expired antibiotic to be disposed of at an official drug destruction source, sent it to a responsible public department, or they returned it to the pharmaceutical

Table 4. Characteristics of drug stores, and methods of disposal of expired antibiotic at 182 drug stores

Responses from drug stores	Number of respondents n (%)
Type of drug store	
Single drug store	173 (95.1)
Multiple-branch drug store	7 (3.8)
Franchise drug store	2 (1.1)
Channel of drug sale	
Retail drug store	158 (86.8)
Retail and wholesale drug store	24 (13.2)
Type of available antibiotic for sale	
Oral antibiotic	182 (100)
Parenteral antibiotic	14 (7.7)
Topical antibiotic	147 (80.8)
Accept return of expired antibiotic from purchaser	
No	177 (97.3)
Yes	5 (2.7)
Method of disposal of expired antibiotic	
Return it to pharmaceutical manufacturer or distributor	120 (65.9)
Throw it away as garbage, in toilet, or in sanitary sewer draining into open public water source	51 (28.0)
Send it to be disposed of at responsible public department	7 (3.8)
Send it to be disposed of at official drug destruction source	4 (2.2)

Additional comments relating to disposal of expired antibiotic

- Guidelines on appropriate disposal of expired antibiotic should be available
- Responsible department for disposal of expired anti-biotic should be available
- Pharmaceutical manufacturer or distributor must accept return of expired antibiotic
- Pharmaceutical manufacturer or distributor must be responsible for appropriate disposal of expired antibiotic
- Public hospital should provide facility for disposal of expired antibiotic
- Expired antibiotic should be disposed of according to the same procedure used for disposal of hazardous waste
- Expired antibiotic should be crushed before disposal since it is garbage
- Expired antibiotic should be disposed of in toilet

Table 5. Characteristics of private medical clinics, and methods of disposal of expired antibiotic at 76 private medical clinics

Responses from private medical clinics	Number of respondents n (%)
Type of available antibiotic	
Oral antibiotic	73 (96.1)
Parenteral antibiotic	56 (73.7)
Topical antibiotic	53 (69.7)
No antibiotic	3 (3.9)
Method of disposal of expired antibiotic	
Throw it away as garbage	46 (60.5)
Return it to pharmaceutical manufacturer or distributor	19 (25.0)
Send it to be disposed of at responsible public department	12 (15.8)
Send it to be disposed of at official drug destruction source	12 (15.8)
Throw it away in toilet	4 (5.3)
Throw it in sanitary sewer draining into open public water source	2 (2.6)

Additional comments relating to disposal of expired antibiotic

- Antibiotic should be returned to pharmaceutical manu-facturer or distributor before its expiration date
- Guidelines on appropriate disposal of expired antibiotic should be available
- Responsible department for disposal of expired anti-biotic should be available in each province
- Reserve appropriate amount of antibiotic
- It should be put in black garbage bag
- It should be disposed of as hazardous waste
- It should be disposed of with heat
- It should be sent to department responsible for disposal of expired antibiotic

manufacturer or distributor. However, some hospitals locally disposed of leftover antibiotic and expired antibiotic by heat, or by throwing it away as garbage or in the toilet. Additional comments on disposal of leftover antibiotic and expired antibiotic included having guidelines on appropriate disposal of expired antibiotic, antibiotic should be returned to the pharmaceutical manufacturer or distributor before its expiration date, and responsible department for disposal of expired antibiotic should be available in each province.

Responses relating to the characteristics of health promotion hospitals, and the methods of disposal of leftover antibiotic and expired antibiotic at 69 health promotion hospitals are shown in Table 7. All of them had antibiotic for distribution, and most of them accepted the return of leftover antibiotic and expired antibiotic from patients. Most health promotion hospitals sent leftover antibiotic and expired antibiotic to be disposed of at the hospitals that provided the antibiotic to them, or they sent it to be disposed of at a responsible public department. However, some health promotion hospitals locally disposed of leftover antibiotic and expired antibiotic

Table 6. Characteristics of general hospitals, and methods of disposal of leftover antibiotic and expired antibiotic at 34 general hospitals

Responses from private general hospitals	Number of respondents n (%)
Type of available antibiotic	
Oral antibiotic	34 (100)
Parenteral antibiotic	34 (100)
Topical antibiotic	31 (91.2)
Presence of guidelines on appropriate disposal of leftover antibiotic and expired antibiotic	
No	6 (17.6)
Yes	28 (82.4)
Method of disposal of leftover antibiotic and expired antibiotic	
Send it to be disposed of at official drug destruction source	18 (52.9)
Return it to pharmaceutical manufacturer or distributor	16 (47.1)
Dispose of it by heat	9 (26.5)
Send it to be disposed of at responsible public department	4 (11.8)
Throw it away as garbage or in toilet	2 (5.9)

Additional comments relating to disposal of leftover antibiotic and expired antibiotic

- Guidelines on appropriate disposal of expired antibiotic should be available and widely distributed
- Antibiotic should be returned to pharmaceutical manu-facturer or distributor before its expiration date
- Responsible department for disposal of expired anti-biotic should be available in each province
- Reserve appropriate amount of antibiotic
- It should be put in black garbage bag
- It should be disposed of as hazardous waste
- It should be disposed of with heat
- It should be sent to responsible department for disposal of expired antibiotic

Table 7. Characteristics of health promotion hospitals, and methods of disposal of leftover antibiotic and expired antibiotic at 69 health promotion hospitals

Responses from health promotion hospitals	Number of respondents n (%)
Type of available antibiotic	
Oral antibiotic	69 (100)
Parenteral antibiotic	0 (0.0)
Accept leftover antibiotic and expired antibiotic from patient	
Yes	61 (88.4)
No	8 (11.6)
Method of disposal of leftover antibiotic and expired antibiotic	
Return it to the general hospital that provided it to the health promotion hospital	44 (63.8)
Dispose of it locally via garbage, toilet, burn, landfill, or public water source	16 (23.2)
Send it to be disposed of at responsible public department	12 (17.4)

Additional comments relating to disposal of leftover antibiotic and expired antibiotic

- Guidelines on appropriate disposal of expired antibiotics should be available and widely distributed
- Antibiotics should be returned to the hospital before their expiration date
- Antibiotics should be disposed by heat in special incinerator
- Antibiotics should be dissolved in water before disposal

by throwing it away as garbage, into the toilet, into a public water source, by burning it, or by putting it in a landfill. Additional comments on disposal of leftover antibiotic and expired antibiotic included having guidelines on appropriate disposal of expired antibiotic, antibiotic should be returned to hospital before its expiration date, it should be disposed of by heat in a special incinerator, and it should be dissolved in water before disposal.

Discussion

The questionnaire response rate of laypeople (70.9%) was higher than that of drug distributors (35.5%). This difference between response rates is likely due to the fact that questionnaires were given directly to laypeople by village health volunteers, whereas the questionnaires for drug distributors were distributed by Thailand Post, and many of the drug distributors (drug stores and private medical clinics) are private sector businesses. It is clear from the responses to the disposal of antibiotics questionnaire that most laypeople and some drug distributors are not aware of the importance of the appropriate disposal of leftover and expired antibiotic, and that they do not know the appropriate method for disposal of antibiotic. Most laypeople and some drug distributors indicated that they would dispose of leftover and expired antibiotic as garbage, in the toilet or into a sanitary sewer that drains into a public water source, any of which would result in contamination of antibiotic in the environment both in community and in hospital. These inappropriate methods of disposal of antibiotic will aggravate the problem of contamination of antibiotic in the environment by adding to the antibiotics that are excreted from patients in hospital and from humans and animals in community. Our ongoing study of antibiotic contamination in waste fluid samples collected from hospitals, open fresh markets, and landfill facilities in community found

antibiotic residues in all samples collected from hospitals and community. Only some amounts of some kinds of antibiotic residues were eliminated by wastewater treatment systems in hospitals. Many kinds of antibiotics are heat stable, and they are not inactivated by heat up to 100°C[10]. Although the concentration of antibiotic in the environment that resulted from inappropriate disposal of leftover antibiotic and expired antibiotic might be low, only a small amount of antibiotic can induce antimicrobial resistance[11-13]. Therefore, raising awareness of the adverse effects of the inappropriate disposal of antibiotic among laypeople and drug distributors, as well as developing and implementing guidelines, laws, and regulations for appropriate disposal of leftover and expired antibiotic are urgently needed.

Antibiotic is classified as hazardous waste by U.S. Environmental Protection Agency, the U.S. Centers for Disease Control and Prevention/National Institute of Occupational Safety and Health, and the U.S. Drug Enforcement Administration, in addition to several other classes of drugs (e.g., cancer drugs). Hazardous waste must be incinerated in a 1200°C hazardous waste incinerator, and then the material that remains after incineration must be stored in a lined hazardous waste landfill. The Thailand Food and Drug Administration (FDA) suggests that leftover antibiotic and expired antibiotic be sent to a healthcare facility (e.g., hospital) that will collect them and send them to be disposed of according to special procedure for disposal of hazardous waste. This likely explains why some laypeople living in rural areas responded that they would return their leftover antibiotic and expired antibiotic to a hospital, because the Thailand FDA launched a campaign to encourage people to return their unused drugs to their nearby hospital. However, this campaign by the Thailand FDA has had low compliance because bringing one's leftover and expired antibiotic to the hospital requires time and cost. Moreover, many hospitals do not accept leftover and expired antibiotics since they have to be disposed of according to special procedure that is unavailable or quite expensive, or they have to send them on to some other responsible department for disposal, and the sending hospital has to cover all related disposal costs. Therefore, all responsible stakeholders should fund and coordinate the development of facilities that can appropriately dispose of leftover antibiotic and expired antibiotic. Those stakeholders should also develop interventions to increase awareness among laypeople and drug distributors regarding the importance of appropriate antibiotic disposal. Guidelines, laws, and regulations are also urgently needed to guide and regulate the disposal of antibiotic so that further contamination of the environment by antibiotics can be minimized. Effective design and implementation of the aforementioned initiatives will help to minimize the emergence of antimicrobial resistance.

Conclusion

The methods that laypeople and various types of drug distributors, including drug stores, private medical clinics, health promotion hospitals, and general hospitals, use to dispose of leftover and expired antibiotic are generally inappropriate, and these behaviors will result in contamination of the environment with antibiotics. This contamination can induce the emergence of antibiotic resistance in bacteria living in the environment, and then these bacteria can be transmitted to humans and animals. Focused initiatives are urgently needed to promote and regulate the safe disposal of antibiotics.

What is already known on this topic?

To the best of our knowledge, there has been no report on the methods of disposal of antibiotic by laypeople and drug distributors in Thailand.

What this study adds?

Information specific to the methods that laypeople and drug distributors use to dispose of leftover antibiotic and expired antibiotic are now available and are reported herein. This information will be useful for developing and distributing guidelines, and for drafting legislation and regulations for both laypeople and drug distributors relative to appropriate methods for disposing of leftover and expired antibiotic. Successful implementation of the aforementioned initiatives will help to minimize contamination of the environment with antibiotic.

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Conflicts of interest

The author declares no personal or professional conflicts of interest relating to any aspect of this study.

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