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Internal Medicine

Indications and patterns of antimicrobial use in pig farms in the southern Kyushu, Japan: large amounts of tetracyclines used to treat respiratory disease in post-weaning and fattening pigs

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ABSTRACT. In Japan, reducing the use of antimicrobials in pig production is a significant issue. However, there are no published reports concerning porcine disease treatment, as related to the age of the pigs and the indications (e.g., organ system) in Japan. In this study, we analyzed the prescription records of 17 farrow-to-finish farms from 2014 to 2018 in southern Kyushu, Japan. The farms' antimicrobial usage was calculated as the active ingredient per population correction unit (PCU) or the number of treated pigs per PCU using the defined daily dose. All data were analyzed according to the indications and production stages (sows, suckling pigs, post-weaning pigs, and fattening pigs). In terms of active ingredients/PCU, tetracyclines were the most commonly used (43.2–59.3%), and the largest amounts of antimicrobials administered through feeds were for treating the respiratory organs of fattening pigs. In terms of the number of treated pigs/PCU, tetracyclines were most frequently used (16.3–31.1%), and a high frequency of antimicrobials administered through feeds was used for the treatment of respiratory organs in post-weaning pigs. In this study, it was confirmed that tetracyclines were used frequently as a herd treatment for respiratory diseases in post-weaning and fattening pigs in southern Kyushu, Japan. The findings suggest that it is necessary to improve the treatment and prevention of respiratory diseases in post-weaning and fattening pigs in order to reduce the frequencies of antimicrobial treatments.

KEY WORDS: antimicrobial usage, defined daily dose, pig, respiratory disease, tetracyclines

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Antimicrobials are a significant tool for controlling a large number of bacterial infections in both animals and humans [7]. However, antimicrobial resistance is a major global issue for public health and food safety [7]. The use of antimicrobials in animals has raised concerns that the selective pressure on the bacterial populations promotes antimicrobial resistance [14]. Therefore, minimization of antimicrobial use in livestock farms is required to reduce the selection pressure risk [7]. In global pig production, oral administration of antimicrobials (through either feed or water) is a common practice [14]. Penicillin and tetracycline classes of antimicrobials are the most common in many countries, and antimicrobials are most commonly administered in the suckling and post-weaning stages [14]. In addition, some countries have succeeded in significantly reducing antimicrobial consumption by analyzing the detailed usage [4, 16, 20, 26].

In Japan, antimicrobial sales for veterinary medicine were higher than those for human medicine [22]. Additionally, a high proportion of antimicrobial use was observed in pig farms [10, 22]. According to one report based on the active ingredients of drugs, 97% of antimicrobials were administered orally [13]. Of these oral administrations, tetracyclines were the most common (39.5–42.8%) [13]. However, there are no published reports associated with disease treatment as related to the age of the pigs and

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the indications (e.g., organ systems) in Japan. In addition, the antimicrobial usage based on drug dosages and treatment frequencies [1, 2] have not been evaluated at the farm level in Japan.

Southern Kyushu is the principal pig-producing area in Japan. Nevertheless, only six farms have been reported for the patterns of antimicrobial use in Kyushu, Japan [13]. The objective of this study was to clarify the main indications (namely, the organ system involved), animal age groups, and the types of administered antimicrobials that are associated with herd treatment, by using two methods of calculating antimicrobial usage. Therefore, we analyzed the annual prescription records of 17 farrow-to-finish farms, from 2014 to 2018, in southern Kyushu, Japan.

MATERIALS AND METHODS

Data collection and database

Antimicrobial usage data were obtained from the original prescription system managed by the Agricultural Mutual Aid Association (AMAA) in Miyazaki Prefecture. At least once a month, veterinarians visited pig farms that were under contract with the AMAA in the Miyazaki prefecture. Based on the clinical signs of the pigs and actual farm conditions when visited, prescriptions for pigs were issued. The prescriptions included the age or production stage of the animal, as well as the initial indications for the prescriptions. The data included the annual records of the prescriptions by 13 veterinarians in 17 pig farms, from 2014 to 2018. Of the 17 farms, 12 were accessible for 5 years, whereas 2–3 were accessible for 3–4 years. A total of 77 annual records were included in the analysis. The sizes of the 17 farrow-to-finish pig farms ranged from 85 to 1,300 sows.

Quantification

To reflect the dose of each drug, the amount of the active ingredient was divided by the defined daily dose (DDD) of each drug. The DDD was the assumed average maintenance dose per day [5]. The DDD for animals in Europe has been published by the European Medicines Agency [6]. In Japan, the equivalent has been published as the average DDD and maximum DDD [21]. Due to its similarity with the actual prescription, a maximum DDD was used in the present study (Table 1) [21]. In addition, the number of pigs treated was calculated by dividing by the standard weight (suckling pigs, 4 kg; post-weaning pigs, 15 kg; fattening pigs, 50 kg; sows, 200 kg) [25]. The formula for the number of treated pigs per prescription is as follows:

The number of treated pigs per prescription

$$= \frac{\text{Amount of active ingredient of each drug } (\text{mg})}{\text{DDD of each drug } (\text{mg / kg / day}) \times \text{standard weight of each production stage } (\text{kg})}$$

It was summed separately according to the farm/year of the different administration routes, antimicrobial classes, age groups, or indications.

To consider the farm size, the antimicrobial usage for each farm/year was calculated using the population correction unit (PCU) [13]. EU member countries routinely report the total amount of antimicrobials sold in food animals as mgs of active ingredients that are adjusted using PCUs [13]. The formula for PCU and antimicrobial usage is as follows:

PCU for each farm/year=number of sows × 240 + number of slaughtered pigs in year × 65

$$\text{Antimicrobial usage} = \frac{\text{Total active ingredient or total number of treated pigs for each farm / year}}{\text{PCU for each farm / year}}$$

The antimicrobial usage by each administration route, antimicrobial class, age group, or indication was compared for each farm/year from 2014 to 2018. Data on the number of sows and slaughtered pigs were obtained from each farm.

Classification of antimicrobial classes, age groups, and indications (organ system)

The antimicrobial classes were classified according to a previous report in Japan [13], based on the WHO Anatomical Therapeutic Chemical Veterinary (ATCvet) classification system. Pigs were classified as follows: suckling pigs (0–28 days, ≤8 kg), post-weaning pigs (29–79 days, 8–40 kg), fattening pigs (≥80 days, ≥40 kg), and sows, including gilts. The indications for antimicrobial medications were categorized by the organ system including the respiratory organs, gastrointestinal tract, urogenital organs, systemic organs, skin, and others [12].

Statistical analysis

All statistical analyses were performed using SAS version 9.4 (SAS Inst. Inc., Cary, NC, USA). A linear mixed-effects model was applied to the analysis. The observational unit was the annual record of antimicrobial usage. A five-year comparison of antimicrobial usage was performed for each antimicrobial class, age group, and indication. The dependent variable was each farm's antimicrobial usage, as shown in Fig. 1, and the independent variables were the year groups (2014 to 2018). A log transformation was used to normalize the antimicrobial usage of each farm. Farm ID numbers were included as random effects, and *P*-values <0.05 were indicative of statistically significant differences.

Table 1. The maximum defined daily dose (DDD) values established in Japan

Substance	Antimicrobial class	Route	DDD (max)	Substance	Antimicrobial class	Route	DDD (max)
Prenteral				Oral			
Oxytetracycline	Tetracyclines	Injection	10	Amoxicillin	Penicillins	Feed or water	10
Oxytetracycline LA[a)]	Tetracyclines	Injection	6.67	Ampicillin	Penicillins	Gavage, feed or water	12
Florfenicol	Amphenicols	Injection	5	Sulfadimethoxine	Sulfonamides	Feed	80
Thiamphenicol	Amphenicols	Injection	30	Sulfamonomethoxine	Sulfonamides	Feed or water	60
Amoxicillin LA[a)]	Penicillins	Injection	7.5	Tylosin	Macrolides	Water	25
Ampicillin	Penicillins	Injection	10	Mirosamicin	Macrolides	Feed	4
Aspoxicillin	Penicillins	Injection	5	Tylosin	Macrolides	Feed	4.4
Benzylpenicillin	Penicillins	Injection	3	Tilmicosin	Macrolides	Feed	8
Mecillinam	Penicillins	Injection	5	Tylvalosin	Macrolides	Feed	2
Cefazolin	Cephalosoprins	Injection	5	Lincomycin	Lincosamides	Water	10
Cefquinome	Cephalosoprins	Injection	2	Lincomycin	Lincosamides	Feed	4.4
Ceftiofur	Cephalosoprins	Injection	3	Gentamicin	Aminoglycosides	Water	0.63
Ceftiofur SD[a)]	Cephalosoprins	Injection	5	Streptomycin	Aminoglycosides	Water	30
Sulfadimethoxine	Sulfonamides	Injection	100	Gentamicin	Aminoglycosides	Gavage	5
Sulfamonomethoxine	Sulfonamides	Injection	100	Apramycin	Aminoglycosides	Feed	4
Erythromycin	Macrolides	Injection	7	Kanamycin	Aminoglycosides	Topical	160
Mirosamicin	Macrolides	Injection	5	Oxolinic acid	Quinolones	Gavage	20
Tilmicosin	Macrolides	Injection	10	Oxolinic acid	Quinolones	Feed	20
Tulathromycin	Macrolides	Injection	2.5	Orbifloxacin	Quinolones	Water	5
Tylosin	Macrolides	Injection	10	Norfloxacin	Quinolones	Feed	10
Lincomycin	Lincosamides	Injection	10	Colistin	Polymyxins	Feed	8
Dihydrostreptomycin (DSM)	Aminoglycosides	Injection	100	Tiamulin	Pleuromutilins	Water	5.85
Kanamycin	Aminoglycosides	Injection	20	Tiamulin A[b)]	Pleuromutilins	Feed	6
Danofloxacin	Quinolones	Injection	1.25	Tiamulin B[b)]	Pleuromutilins	Feed	12
Enrofloxacin	Quinolones	Injection	2.5	Valnemulin	Pleuromutilins	Feed	4
Enrofloxacin SD[a)]	Quinolones	Injection	7.5	Bicozamycin	Other antibacterials	Gavage, feed or water	10
Marbofloxacin	Quinolones	Injection	2	Chlortetracycline_Sulfadimidine	Tetracyclines (combi.)	Feed	8
Orbifloxacin	Quinolones	Injection	5		Sulfonamides (combi.)	Feed	8
Tiamulin	Pleuromutilins	Injection	10	Oxytetracycline _fradiomycin A[b)]	Tetracyclines (combi.)	Feed	10
Fosfomycin	Other antibacterials	Injection	20		Aminoglycosides (combi.)	Feed	7
Benzylpenicillin_DSM	Penicillins (combi.)	Injection	40	Oxytetracycline _fradiomycin B[b)]	Tetracyclines (combi.)	Feed	9.2
	Aminoglycosides (combi.)	Injection	7.5		Aminoglycosides (combi.)	Feed	7
Sulfadoxine_trimthoprim	Sulfonamides (combi.)	Injection	12	Benzylpenicillin_kanamycin	Penicillins (combi.)	Feed	1.44
	Trimthoprim (combi.)	Injection	25		Aminoglycosides (combi.)	Feed	7
				Benzylpenicillin_streptomycin	Penicillins (combi.)	Feed	1.44
Oral					Aminoglycosides (combi.)	Feed	7
Chlortetracycline	Tetracyclines	Water	30	Sulfamethoxazole_trimethoprim	Sulfonamides (combi.)	Water	10.41
Doxycycline	Tetracyclines	Water	24		Trimthoprim (combi.)	Water	2.09
Oxytetracycline	Tetracyclines	Water	11	Sulfamonomethoxine_ormetoprim	Sulfonamides (combi.)	Water	15
Chlortetracycline	Tetracyclines	Feed	17.6		Trimthoprim (combi.)	Water	5
Doxycycline	Tetracyclines	Feed	12	Sulfadimethoxine_trimethoprim	Sulfonamides (combi.)	Feed	36
Oxytetracycline	Tetracyclines	Feed	16		Trimthoprim (combi.)	Feed	4
Florfenicol	Amphenicols	Water	2	Sulfamethoxazole_trimethoprim	Sulfonamides (combi.)	Feed	6.67
Florfenicol	Amphenicols	Feed	2		Trimthoprim (combi.)	Feed	1.33
Thiamphenicol	Amphenicols	Feed	8	Sulfamonomethoxine_ormetoprim	Sulfonamides (combi.)	Feed	7.2
					Trimthoprim (combi.)	Feed	2.4

[a)] LA: long acting, SD: single dose. [b)] Oxytetracycline_fradiomycin A: manufacturer N, Oxytetracycline_fradiomycin B: manufacturer P, Tiamulin A: manufacturer Z, Ka, E, Tiamulin B: manufacturer Ky, F.

RESULTS

Antimicrobial usage according to administration type, class, age group, and indication by organ system.

The means of antimicrobial usage were 191.9–242.9 mg/PCU (SD=199.5–251.4) and 0.95–1.44 heads/PCU (SD=0.59–1.85) from 2014 to 2018, with no significant differences (Table 2). For the number of treated pigs/PCU, the antimicrobials administered through feed and through water were 0.84–1.25 heads/PCU (SD=0.62–1.84) and 0.10–0.23 heads/PCU (SD=0.10–0.27), respectively (Table 2). Therefore, 93.4–94.7% of the antimicrobials were administered orally. Relatively, parenteral administration was low (0.06–0.10 heads/PCU, SD=0.07–0.11) (Table 2).

For each antimicrobial class, age group, and indication, there was no significant difference between the different years observed. Tetracyclines were the most frequently used active ingredient (mg)/PCU from 2014 to 2018 (43.2–59.3%), followed by sulfonamides (0.6–14.4%) (Fig. 1a). Whereas, on the number of treated pigs (heads)/PCU, tetracyclines (17.3–34.2%) were most frequently used, followed by aminoglycosides (10.4–18.8%) (Fig. 1a). The highest frequency of antimicrobials was used in the post-weaning stage (58.7–68.5%), followed by the fattening stage (27.3–34.6%) (Fig. 1b). The antimicrobials were most commonly used to treat the respiratory organs (55.0–65.0%), followed by the gastrointestinal tract (33.5–42.3%). (Fig. 1c).

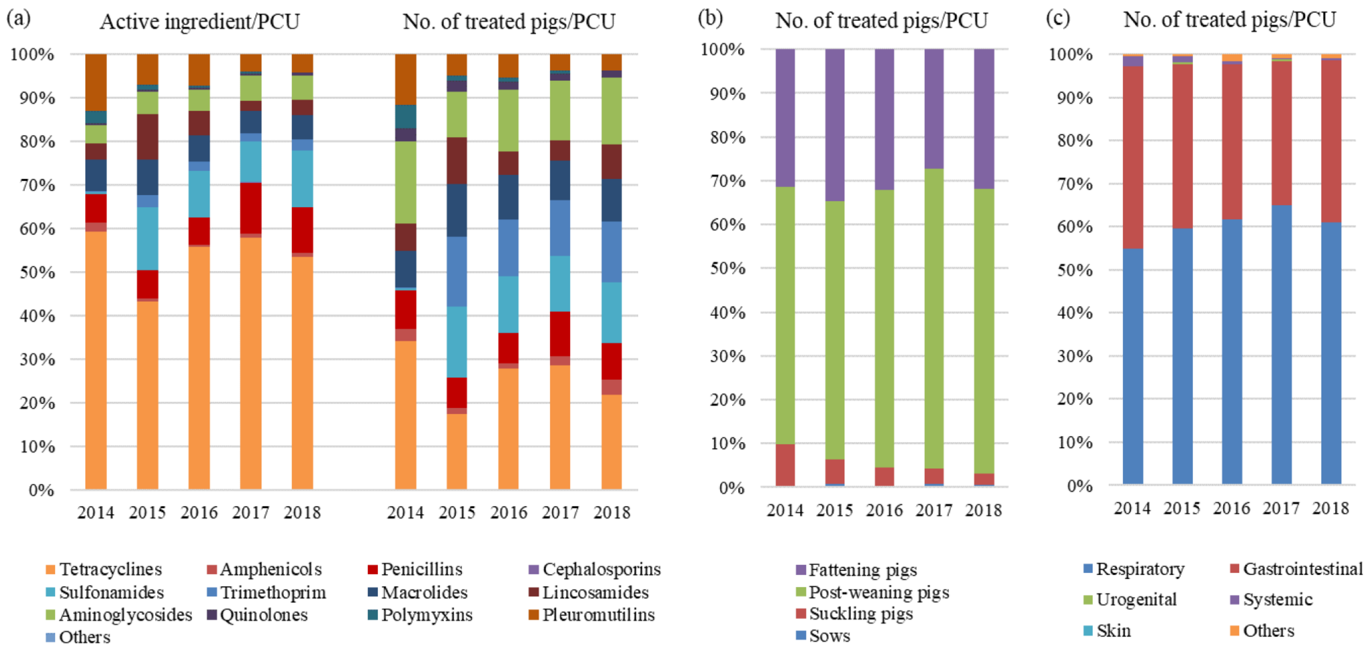

Fig. 1. Changes in antimicrobial usage over 5 years by class (a), age group (b), and indication (organ system) (c). (a) The antimicrobial usage based on the active ingredient (mg)/population correcthion unit (PCU) and the numbers of treated pigs (heads)/PCU were compared. Thirteen antimicrobial classes were compared based on the WHO ATCvet classification system. In terms of active ingredients (mg)/PCU, tetracyclines (43.2–59.3%) were most frequently used, followed by sulfonamides (0.6–14.4%). While, for the number of treated pigs (heads)/PCU, tetracyclines (17.3–34.2%) were most frequently used, followed by aminoglycosides (10.4–18.8%). (b) The highest frequency of antimicrobials was used in the post-weaning stage (58.7–68.5%), followed by the fattening stage (27.3–34.6%). (c) Six indications according to the organ systems. The antimicrobials were most frequently used to treat respiratory organs (55.0–65.0%), followed by the gastrointestinal tract (33.5–42.3%).

Table 2. Mean and variation of antimicrobial usage in 17 farms

Year	n	Active ingredients (mg)/PCU		No. of treated pigs (heads)/PCU		Medication route					
		Total		Total		Through feed		Through water		Parenteral	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
2014	12	216.1	199.5	1.10	0.59	0.92	0.62	0.23	0.27	0.08	0.09
2015	14	242.9	251.4	1.44	1.85	1.25	1.84	0.14	0.25	0.10	0.11
2016	17	237.5	239.2	1.23	1.65	1.12	1.66	0.09	0.14	0.07	0.07
2017	17	227.1	227.5	1.13	1.53	1.00	1.53	0.12	0.15	0.06	0.08
2018	17	191.9	205.4	0.95	1.38	0.84	1.38	0.10	0.10	0.06	0.07

The value of mg/population correcthion unit (PCU) rounds off the second decimal point, and heads/PCU rounds third decimal point.

Antimicrobial classes administered via feeds for post-weaning and fattening pigs to treat their respiratory organs and gastrointestinal tracts (active ingredient/PCU and number of treated pigs/PCU)

The largest amount of antimicrobials was used for respiratory organs in fattening pigs (1,223.0–2,035.9 mg/PCU), followed by respiratory organs in post-weaning pigs (632.7–1,039.4 mg/PCU) (Fig. 2a). Tetracyclines were most commonly used for treating the respiratory organs of fattening and post-weaning pigs (956.8–1,525.7 and 284.4–704.9 mg/PCU, respectively) (Fig. 2a). Whereas, regarding the number of treated pigs/PCUs, respiratory organs in post-weaning pigs (3.65–7.87 heads/PCU) were treated most frequently, followed by the gastrointestinal tract in post-weaning pigs (2.76–4.75 heads/PCU) and respiratory organs in fattening pigs (2.59–4.16 heads/PCU) (Fig. 2b). Tetracyclines were used frequently for treating the respiratory organs in post-weaning and fattening pigs (1.52–3.34 and 1.42–2.16 heads/PCU, respectively), and aminoglycosides were used for treating the gastrointestinal tract in post-weaning pigs (1.20–2.31 heads/PCU) (Fig. 2b).

DISCUSSION

This study revealed that antimicrobial treatments are widely used in southern Kyushu, Japan during the post-weaning and fattening stages. As in previous reports [12, 19], post-weaning pigs were found to be treated most frequently. However, the

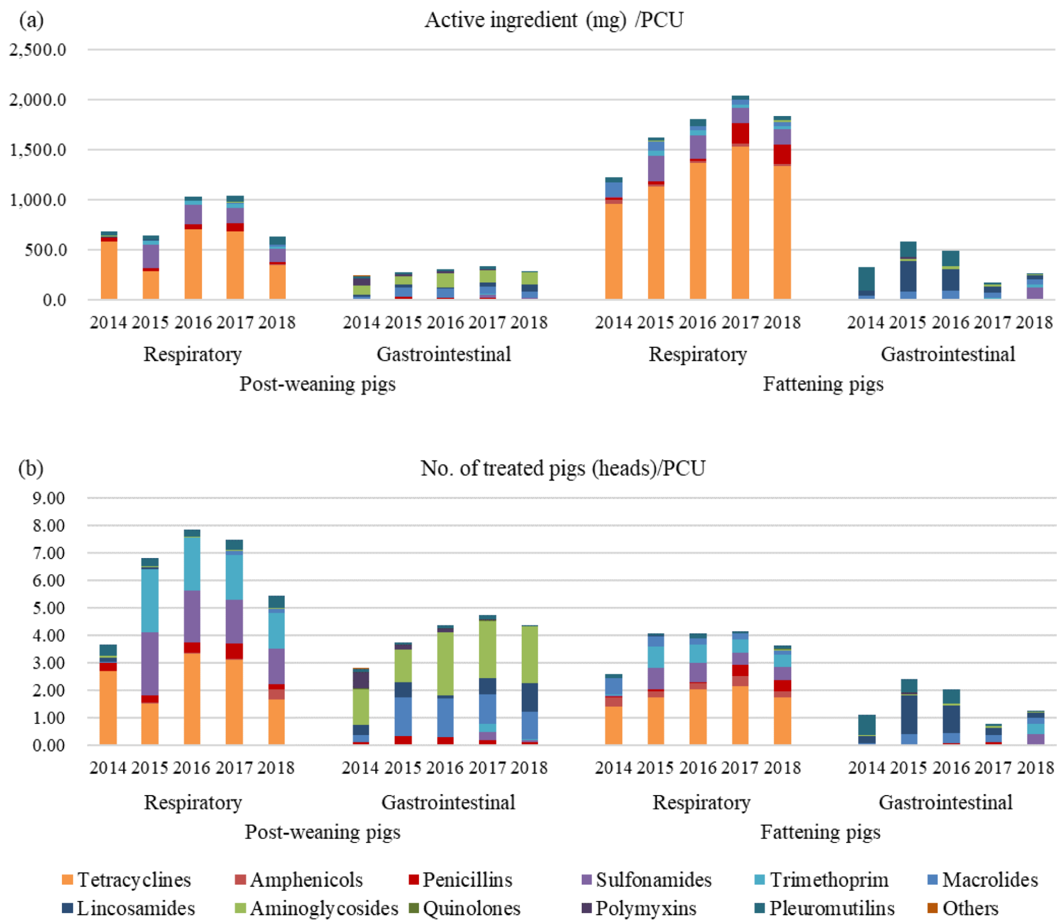

Fig. 2. Antimicrobial classes administered through feeds for post-weaning and fattening pigs to treat the respiratory organs and gastrointestinal tract. A different trend was seen between the active ingredient (mg)/population correcthion unit (PCU) (a) and the number of treated pigs (heads)/PCU (b). (a) The largest amounts of antimicrobials were used for treating the respiratory organs of fattening pigs (1,223.0–2,035.9 mg/PCU), followed by the respiratory organs of post-weaning pigs (632.7–1,039.4 mg/PCU). Tetracyclines were used the most to treat the respiratory organs of the fattening and post-weaning pigs (956.8–1,525.7 and 284.4–704.9 mg/PCU, respectively). (b) Respiratory organs in post-weaning pigs (3.65–7.87 heads/PCU) were treated most frequently, followed by the gastrointestinal tract of post-weaning pigs (2.76–4.75 heads/PCU) and the respiratory organs of fattening pigs (2.59–4.16 heads/PCU). Tetracyclines were used frequently for the treatment of the respiratory organs of post-weaning and fattening pigs (1.52–3.34 and 1.42–2.16 heads/PCU, respectively), and aminoglycosides were used for treating the gastrointestinal tract of post-weaning pigs (1.20–2.31 heads/PCU).

proportion of antimicrobial usage among fattening pigs was high, compared to usage in global pig production [14]. Furthermore, it was found that respiratory diseases were strongly associated with antimicrobial usage, most of which came from the frequency of tetracyclines use. Nevertheless, the high proportion of tetracycline usage is well known in Japanese pig production, and yet, there have been no previous reports of the age or diseases associated with its prescription [10, 11, 13]. Hosoi *et al.* [10] suggested that the frequency and significance of bacterial respiratory diseases may have contributed to the frequent use of tetracyclines in Japan. Tetracyclines are readily available at a low cost and are widely used for the treatment of respiratory diseases, such as *Actinobacillus pleuropneumoniae* infections [10]. This concept was supported by the findings of our study. Porcine respiratory disease complex (PRDC) is often multifactorial, involving different combinations of viruses and bacteria (*A. pleuropneumoniae, Bordetella bronchiseptica,* and *Mycoplasma hyopneumoniae*), causing severe losses [8, 18]. *Streptococcus suis* and *Haemophilus parasuis* are also associated with PRDC [8]. Tetracyclines could have been used to treat these bacterial pathogens in post-weaning and fattening pigs. In contrast, tetracyclines were not used for the herd treatment of gastrointestinal diseases. The most commonly used antimicrobial class for the gastrointestinal tract of post-weaning pigs is aminoglycosides. Aminoglycosides are poorly absorbed from the normal gastrointestinal tract [15]. Hence, many aminoglycosides could have been used efficiently to treat digestive infections such as diarrhea. Furthermore, in our clinical laboratory in southern Kyushu, Japan, *A. pleuropneumoniae* and *S. suis* were frequently detected in respiratory diseases, and *Escherichia coli* was most frequently detected in gastrointestinal diseases during the 5-year study period. Therefore, these pathogens should lead to differences in antimicrobials.

The DDD, which reflects the antimicrobial dose, allowed for a comparison of drug usage. Dividing the DDD by the standard weight of the pigs revealed the frequency of antimicrobial administration as the number of treated pigs. In terms of the number of treated pigs (heads)/PCU values from 2014 to 2018, aminoglycosides (13.1–23.6%) were the second most frequently used, while for the active ingredient (mg)/PCU, sulfonamides (0.6–14.4%) were the second most used. This discrepancy was brought about by considering the dose of the drug and the weight of the dosing stage. In addition, the proportion of tetracyclines used differed between the two methods of calculating usage. Although active ingredient/PCU values have been reported in EU countries for country-to-country comparisons [13], pig producers and veterinarians in Japan may note a discrepancy between their actual usages at the farm level. Therefore, further studies are needed to evaluate the antimicrobial use in Japanese pig production.

Indicators based on drug dosages and treatment frequencies have been used in many studies [2]. In Denmark, oral administration is commonly used in post-weaning and fattening pigs [12]. The most commonly used antimicrobial class for all ages was tetracyclines, and gastrointestinal infections accounted for 74–83% and 56–65% of the total antimicrobial usage in post-weaning and fattening pigs, respectively [12]. In the present study, tetracyclines were frequently used to treat respiratory disease in post-weaning and fattening pigs. The indications for tetracyclines differed from those of Danish pig production. In Germany, 98% of the antimicrobials were administered orally. For all ages, respiratory infections were the main indication for antimicrobial prescriptions [25]. Amoxicillin was mainly administered to treat respiratory diseases in post-weaning and fattening pigs, followed by tetracycline and chlortetracycline [25]. Intestinal diseases were treated with colistin in post-weaning pigs and tylosin in fattening pigs [25]. Our study showed that tetracyclines and aminoglycosides were used to treat respiratory and gastrointestinal diseases respectively. In Germany, the classes of antimicrobials commonly used for respiratory and intestinal diseases differ from our results. In Canada, penicillin was administered most frequently (34.9%), and the main target disease was *S. suis* infection [9]. In Belgium, France, Germany, and Sweden, group treatment through feed or water was the most common method for treating pigs in the herd [19], and aminopenicillins were administered to post-weaning pigs most frequently [19]. The use of different types of penicillin, including aminopenicillin, was not high in this study. In this way, the patterns of antimicrobial use varied across countries. As some countries have succeeded in significantly reducing the consumptions of antimicrobials by analyzing their own antimicrobial usage [4, 16, 20, 26], the detailed analysis conducted by this study should help control antimicrobial use in Japanese pig production.

Japan's national action plan included a quantitative target (33% or lower) in order to lower the proportion of tetracycline-resistant *E. coli* in food-producing animals [13, 22]. Although the relationship between tetracycline use and the isolation rate of resistant bacteria on general farms was unknown, the tetracycline sales for livestock remained the highest, at 41.9–44.0% from 2013 to 2016 [22]. In addition, the isolation rate of resistant bacteria was 39.9% at the farms in 2015 and 40.8% at the slaughterhouses in 2017 [22, 23]. Toya *et al*. [24] reported that changing medication methods and improving feed management reduced antimicrobial treatment on farms in Japan. To reduce tetracycline use, it is important to control the onset of respiratory diseases in pig farms. In addition, Isomura *et al*. [11] reported that Japanese farms with a lower post-weaning mortality risk and complete control of pig flow had lower doxycycline and amphenicol usages. Therefore, disease prevention methods such as farm biosecurity, breeding environment improvement, feeding density, and nutritional management [3, 11, 17, 20] may be necessary to reduce tetracycline use in Japanese pig farms.

In this study, data were obtained from 17 farms in southern Kyushu, Japan. Southern Kyushu, Japan, is the principal pig-producing area in Japan. The mean farm size of all farrow-to-finish farms was 295.6–369.6 breeding sows, and the mean antimicrobial usage frequency was 191.9–242.9 mg/PCU. According to a survey by the Japan Pork Producers Association, 85.9% of the subjects were farrow-to-finish farms, while the mean farm size was 247 breeding sows, as provided in a domestic survey [13]. In addition, the survey indicated that the mean antimicrobial usage in Japan from 2015 to 2017 was 401–437 mg/PCU [13]. This indicates that the results obtained in the present study were not far from the situation in Japanese pig farms.

As a limitation, our results must be interpreted with caution given the potential biases associated with our reference population compared with the entire Japanese swine population. In the present study, medical prescriptions based on the actual conditions of the pig farm when the veterinarian visited were used. However, it was not possible to precisely evaluate the producer's compliance in following the prescription.

In conclusion, we confirmed that large amounts of tetracyclines were frequently used in pig farms in southern Kyushu, Japan. Respiratory diseases in the post-weaning and fattening stages were associated with increases in antimicrobial usage. These results suggest that preventive measures against respiratory diseases are necessary to reduce the use of antimicrobials, such as tetracyclines, in pig farms. In addition, the proportion of antimicrobial use differed between the two methods of calculating usage, namely the active ingredient (mg)/PCU and the numbers of treated pigs (heads)/PCU. Therefore, further consideration is needed to evaluate the antimicrobial use in Japanese pig production.

POTENTIAL CONFLICTS OF INTEREST. The authors have nothing to disclose.

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