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EVALUATION OF THE KNOWLEDGE OF PIG FARMERS IN COMMERCIAL FARMS REGARDING THE PRUDENT USE OF ANTIMICROBIALS IN PIG FARMING IN RIO GRANDE DO SUL

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Abstract: Brazil is the 4th largest producer and exporter of pork in the world. In 2023, the Southern region accounted for 73% of slaughters, with Rio Grande do Sul (RS) ranking third nationally. The intensification of swine farming has brought economic gains but also an increase in the use of antimicrobials (AMs), employed in disease prevention and control. This scenario raises public health concerns regarding antimicrobial resistance (AMR), pressuring the production chain to adopt more prudent practices - a challenge for producers who fear negative impacts on productivity and profitability. This study aimed to assess the knowledge of pig producers in RS regarding the prudent use of antimicrobials, through an exploratory and descriptive survey, using questionnaires applied to 97 commercial farms between January 2022 and April 2023. Results showed that all producers were assisted by technicians from integrator companies (100%) and were aware of AM use in water (71.9%) and feed (74.2%), mainly for disease prevention (77.8%). However, there was no consensus on the possibility of reducing their use, and 47% were unaware of alternatives. The main obstacles to adopting alternative practices included costs (67%), lack of additional remuneration (58.8%), and uncertain effectiveness of the measures (58.8%). Although they recognize the risks of AMR, 90.7% of producers do not believe in the feasibility of completely eliminating AM use. The study reinforces the need for educational strategies and public policies to promote the responsible use of these drugs.

Keywords: antibiotics; pig production; antimicrobial stewardship.

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AVALIAÇÃO DO CONHECIMENTO DOS PRODUTORES RURAIS DE GRANJAS DE SUÍNOS PARA FINS COMERCIAIS QUANTO AO USO PRUDENTE DE ANTIMICROBIANOS NA SUINOCULTURA NO RIO GRANDE DO SUL

Resumo: O Brasil é o 4º maior produtor e exportador mundial de carne suína. Em 2023, a região Sul concentrou 73% do abate, com o Rio Grande do Sul (RS) ocupando a terceira posição nacional. A intensificação da suinocultura trouxe ganhos econômicos, mas também o aumento do uso de antimicrobianos (ATM), empregados na prevenção e controle de doenças. Esse cenário levanta preocupações em saúde pública, quanto à resistência antimicrobiana, pressionando a cadeia produtiva a adotar práticas mais prudentes, o que representa um desafio para os produtores, que temem impactos na produtividade e rentabilidade. Assim, este estudo objetivou avaliar o conhecimento de produtores de suínos do RS quanto ao uso prudente de antimicrobianos, por meio de pesquisa exploratória e descritiva, com aplicação de questionários a 97 granjas comerciais entre janeiro de 2022 e abril de 2023. Os resultados mostraram que todos os produtores eram assistidos por técnicos das empresas integradoras (100%) e estavam cientes do uso de ATM na água (71,9%) e na ração (74,2%), principalmente para prevenção de doenças (77,8%). Contudo, não houve consenso sobre a possibilidade de reduzir seu uso, e 47% desconheciam alternativas para tanto. Os principais obstáculos à adoção de práticas alternativas incluíram os custos (67%), a ausência de remuneração adicional (58,8%) e a eficácia incerta das medidas (58,8%). Embora reconheçam os riscos da resistência antimicrobiana, 90,7% dos produtores não acreditam na viabilidade de eliminar totalmente o uso de ATM. A pesquisa reforça a necessidade de estratégias educacionais e políticas públicas que promovam o uso responsável desses medicamentos.

Palavras-chave: antibióticos; produção de suínos; gerenciamento do uso de antimicrobianos.

1 INTRODUCTION

In Brazil, from 1980 to 2023, pork production grew by 418%, while exports increased more than 1,200 times, positioning the country as the 4th largest producer and exporter of pork in the world. Additionally, in 2023, the southern region was responsible for 73% of the national pig slaughter in the country, with the state of Rio Grande do Sul ranking the third position nationally (ABPA, 2024). In this context, the use of intensive breeding systems in pig farming was important to generating significant gains in economies of scale, productivity, and logistics. On the other hand, this practice also increased the spread of infectious diseases and the level of stress in animals, making the use of antimicrobials (AM) essential for the prevention and control of infections (Morés *et al.*, 2018).

However, the use of AM is often marked by practices that compromise therapeutic efficacy and contribute to antimicrobial resistance (AMR). Notably, antimicrobials are frequently administered as growth promoters or used preventively and therapeutically without precise clinical diagnosis. The lack of individualized treatment further exposes healthy animals to unnecessary antibiotic therapy, increasing the risk of selecting resistant microorganisms. In Brazil, the consumption of antimicrobials in pig farming is higher than in other major producing countries, reflecting a concerning pattern of use (Repik *et al.*, 2022).

In parallel with this scenario, there is a growing concern about antimicrobial resistance (AMR) in public health, which has pressured production chains to reduce the use of antimicrobials in livestock (Zhang *et al.*, 2017). According to Morés *et al.* (2018), this

concern may significantly influence global meat production over the next decade, potentially representing a major barrier to the growth of the animal protein sector or, alternatively, a competitive advantage for producers who are able to meet the new requirements. For producers, however, this reduction is challenging, as it may negatively affect both productive and economic performance of the farm, especially in critical phases such nursery, where the withdrawal of these drugs can result in a drop in productivity (Toledo *et al.*, 2017). In this sense, it is interesting to note that studies in Europe and China indicate that, in order to reduce the use of AM, it is crucial to understand the motivations of producers and assess the biosecurity characteristics of farms (Visschers *et al.*, 2016; Yang *et al.*, 2019). Furthermore, the choice and pattern of antimicrobial consumption vary geographically, influenced by factors such as the production system, the purpose of the production, and the existence of legislative policies (Manyi-Loh *et al.*, 2018). In consequence, the management of risk factors by rural producers, which include everything from previous experience to access to over-the-counter medications, plays a fundamental role in the demand for AM (Raboisson *et al.*, 2020; Adebowale *et al.*, 2020).

Considering the above, it is important to clarify that the use of antimicrobials in pig farming is a routine practice, but poorly regulated and documented. Likewise, the knowledge of pig producers regarding the use of these medications is also not well described or understood due to insufficient research. For this reason, to better understand the knowledge of rural producers regarding the use of antimicrobials, an exploratory descriptive study was conducted with pig farmers on commercial farms of the integrated production system in the state of Rio Grande do Sul.

2 MATERIAL AND METHODS

An exploratory descriptive study was conducted with producers of commercial pig farms in Rio Grande do Sul, focusing on integrated farms dedicated to the production and distribution of pigs for slaughter. The selection of farms was based on a stratified sampling of a total of 7,575 farms registered in the database of the Secretariat of Agriculture, Livestock, Sustainable Production and Irrigation (SEAPI) in 2020.

The criteria for inclusion of properties in the study were: active commercial farms in the SEAPI database, associated with one of the eight integrators that agreed to participate in the study, out of the 21 existing, and focused on pig farming for meat production. These integrators represented 58% of the integrated farms and 61% of the commercial pig herd in Rio Grande do Sul in 2020. Although the independent production system did not express interest in participating, it accounted for 19.5% of the registered pig properties and only 7% of the state's commercial pig herd (Rio Grande Do Sul, 2020). Subsistence farms, independent farms and those with fewer than 50 pigs in farrow to finish systems were excluded. This exclusion is justified by the study's focus on commercial pig farming, thus not covering farms aimed at subsistence consumption or those that access the marketing channels of the pork production in a limited and marginal way. After applying these criteria, 3,516 farms remained eligible to participate in the research (Table 1).

Table 1. Pig farms for commercial purposes eligible for sample calculation, according to the integrators' consent

Production system	Number of farms (*f*)	%	Total pigs (*f*)	%
Farrow to finish > 50 animals	9	0	2.008	0
Piglet Rearing	374	11	541.106	18
Piglet Production	230	7	650.907	21
Finishers	2.903	83	1.859.400	61
Total participants	3.516	100	3.053.421	100
Total integrated system RS	6.096	0	5.022.171	0
Participants/ Integrated system RS	58%		61%	

In this context, the term "production system" refers to the functional classification of farms based on their role in the pig production chain – such as piglet production, rearing, and finishing – rather than the organizational model of production (e.g., integrated or independent systems). This terminology was adopted to align with the stratified sampling approach.

A stratified random sampling was carried out by production systems, into Piglet Producers (PP), Piglet Rearing (PR), Finishers (F) and Farrow to finish, and adjusted by integrator, based on the total number of pigs registered in 2020. PP refers to specialized establishments dedicated to the production of piglets, which are subsequently marketed or transferred for fattening; PR corresponds to piglet rearing, where weaned piglets are raised; and F designates units responsible for the growth and fattening of pigs until slaughter. The initial sample size estimate (n_0) was calculated using the formula $n_0 = 1/E_0^2$, with a tolerable sampling error of 10% ($E_0 = 0.1$), resulting in $n_0 = 100$. Although a 5% sampling error was initially considered, due to the high workload involved in data collection and to ensure participant engagement, the sampling error was increased to 10%. Subsequently, based on the total of 3,516 eligible farms (N), the corrected sample size (n) was determined using the formula $n = (N^*n_0)/(N+n_0)$, yielding a final sample of 97 farms (Barbetta, 2012).

The distribution by production phase followed this estimate, with Farrow to finish farms lacking sufficient representation for inclusion (Table 2).

Table 2. Sample of commercial pig farms by production system - 10% margin of error

Production phase	Number of farms (*f*)	%	Total pigs (*f*)	%	Sample
Farrow to finish > 50 animals	9	0	2.008	0	0
Piglet rearing	374	11	541.106	18	17
Piglet Producers	230	7	650.907	21	21
Finishers	2.903	83	1.859.400	61	59
Total participants	3.516	100	3.053.421	100	97

Additionally, adjustments were made due to the low representation of certain production systems in some integrators, ensuring a minimum of three farms per integrator (one PP one PR and one F, balancing the number of sampled farms between the two largest integrators, and increasing the number of farms sampled from specific integrators (B, C, E and H) according to the frequency of total pigs. The increase followed these criteria: frequency between 0.01 – 0.04 (1 additional farm), 0.08 – 0.12 (2 farms), and 0.24 – 0.29 (4 farms).

Table 3 presents the adjusted weighting considered appropriate for execution of this study.

Table 3. Number of farms to be sampled per integrator, by production stage, after weighting adjustment

Integrator code		PP	PR	F	Total number of farms in the sample
A					
	Sample	4	1	15	20
B					
	Sample	2	1	4	7
C					
	Sample	1	1	2	4
D					
	Sample	3	5	9	17
E					
	Sample	2	2	4	8
F					
	Sample	4	4	5	13
G					
	Sample	3	3	19	25
H					
	Sample	1	1	1	3
Total		20	18	59	97

The farms were randomly selected from SEAPI database using Microsoft Excel 2013. During the study, two farms initially classified as PR were replaced with two F due to commercial confidentially agreements between two integrators. Thus, the final sample consisted of 97 farms: 20 PP, 16 PR, and 61 F (Table 4).

Table 4. Number of farms to be sampled per integrator, by production system, after weighting adjustment and substitution

Integrator code		PP	PR	F	Total number of farms in the sample
A					
	Sample	4	1	15	20
B					
	Sample	2	1	4	7
C					
	Sample	1	1	2	4
D					
	Sample	3	5	9	17
E					
	Sample	2	0	6	8
F					
	Sample	4	4	5	13
G					
	Sample	3	3	19	25
H					
	Sample	1	1	1	3
Total		20	16	61	97

Structured questionnaires were administered on each farm to gather qualitative data on antimicrobial use and bacterial resistance in humans and animals, and opinions on public policies related to antimicrobial use. The questionnaire consisted of 24 questions and was applied during on-farm visits.

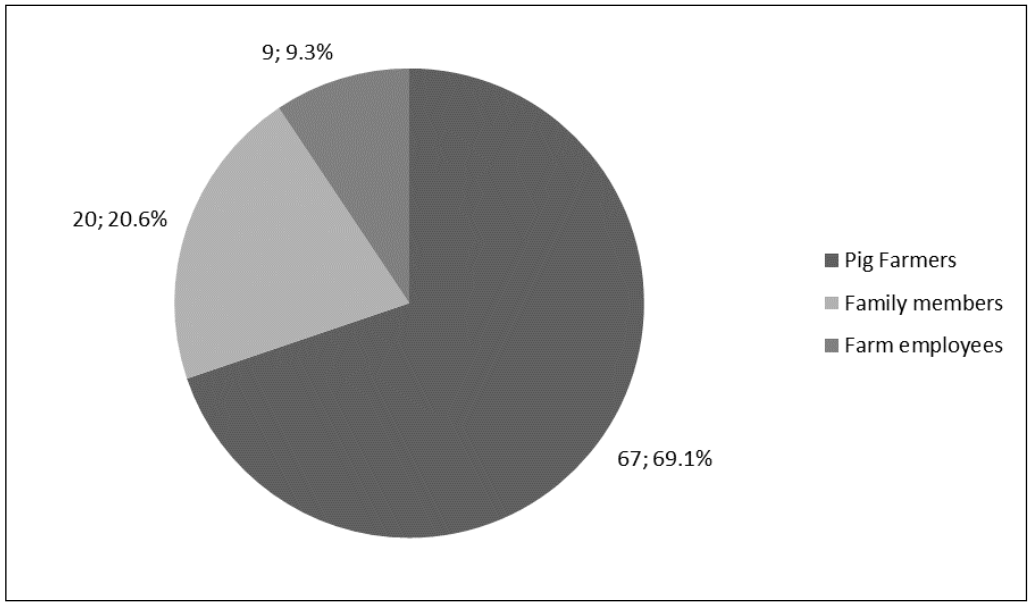
Before full implementation, the questionnaire was pretested on a small sample of conveniently selected farms to assess application time and identify potential comprehension issues. Based on the results, the questionnaire was refined, and a standardized interview and data collection protocol was developed to ensure consistency across interviewers. The data collection process was supported by staff from SEAPI's Agricultural Defense Inspectorates. All data were organized and analyzed using Microsoft Office Excel 2013.

All participants in the study were previously informed about the study objectives, data collection procedures, and the implications of their participation. To ensure ethical compliance, participants were guaranteed anonymity, and was clearly stated that their participation was voluntary and that they could withdraw at any time without penalty.

3 RESULTS AND DISCUSSION

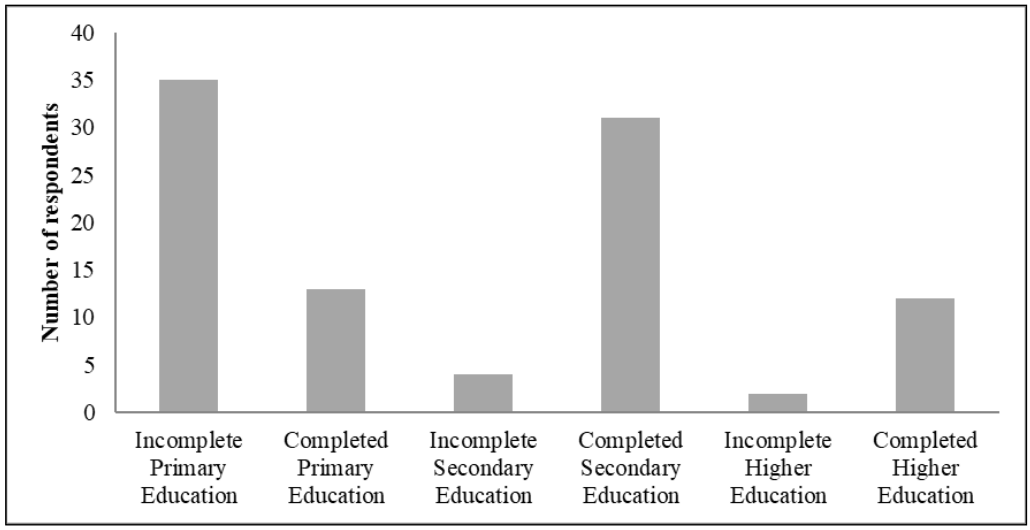
As shown in Figure 1, the questionnaires used in the study were answered mainly by the pig farmer (69.1%, n = 67). In their absence, the data were provided by family members involved in the activity (20.6%, n = 20) or by farm employees (9.3%, n = 9).

Figure 1. Role of respondents



As a result, the analysis revealed that 82% of the participating pig farms (n = 80) had up to three people specifically involved in pig farming, while only 18% of these (n = 9) had more than four individuals, with a range from 4 to 33. The average age of the interviewees was 48 years (ranging from 22 to 75 years), and only 21% of them were in the age group of 60 years or older. The average experience in pig farming was 21 years, with a range from 1 to 60 years. Regarding education (Figure 2), it was observed that 36.1% (n = 35) of the interviewees had incomplete primary education, 32% (n = 31) had completed secondary education, 13.4% (n = 13) had completed primary education and only 12.4% (n = 12) had completed higher education. Among those with higher education, only five were pig farmers.

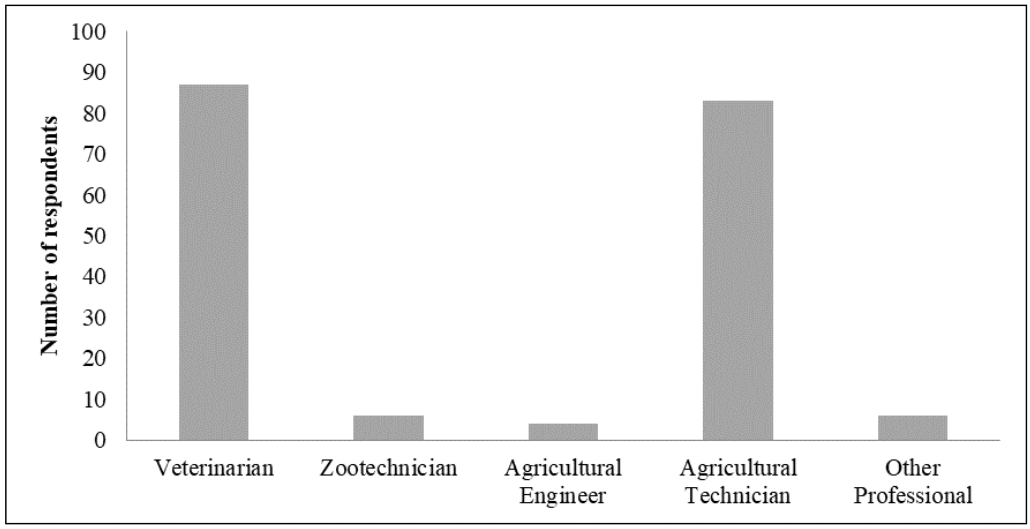
Figure 2. Educational level of survey participants



The predominance of swine farms with up to three individuals involved characterizes a family-based production structure. The average age of respondents (48 years), with 21% over 60, highlights the aging of the rural workforce, underscoring the urgency of public policies aimed at generational succession and the promotion of agricultural activity among younger populations. Although producers report an average of 21 years of experience in the field, educational background data indicate the need for training and rural extension strategies tailored to the participants' profiles. Educational initiatives that employ clear, accessible language and a practical focus tend to be more effective, particularly in technical subjects such as the prudent use of antimicrobials, contributing to improved animal health and production sustainability.

All study participants (100%, n = 97) reported receiving technical assistance from pork integrator companies. As shown in Figure 3, most of this assistance was provided by veterinarians (89.7%, n = 87) and agricultural technicians (85.6%, n = 83). In terms of the frequency of these professionals' visit, 64.9% (n = 63) of the interviewees reported them as monthly, 20.9% (n = 20) as biweekly and 9.3% (n = 9) as weekly. Only 3.1% reported receiving technical visits only when requested.

Figure 3. Categories of professionals involved in technical assistance to pig farms in RS



Following this, to address the use of antimicrobials in pig production, interviewees were asked whether they used injectable antimicrobials on the animals, considering that this method of administration often directly involves the farmer. The response was affirmative for 99% (n = 96) of the participants. The criteria for choosing the antimicrobials were mostly based on technical guidance provided by the pork integration company (89.7%; n = 87), while 10.3% (n = 10) relied on the pig farmer's own experience.

Next, respondents were asked whether antimicrobials were administered via the pigs' drinking water. It was found that 71.9% (n = 69) of respondents used this method, always following the technical guidance provided by the integrators (100%, n = 97).

Finally, it was verified whether producers were aware of the administration of antimicrobials via feed, which is carried out at the factory and supplied according to the integrators' protocols. Of the respondents, 74.2% confirmed being informed about this practice and indicated that the main purpose was disease prevention (77.8%, n = 56).

This information highlights the crucial role of technical guidance from integrators in the selection and administration of antimicrobials. Most of producers are aware of how these drugs are administered, whether they are applied directly or supplied via feed. Additionally, the understanding that the primary purpose of using antimicrobials in feed is disease prevention aligns with the goals of pork integrators companies.

In the second block of questions, pig farmers were asked about the possibility and necessity of reducing the use of antimicrobials in pig farming. The sample showed a division of opinions, with 55.7% (n – 54) of producers believing in the possibility of reducing the use of these drugs, while 44.3% (n = 43) of these disagreed. In addition, it is interesting to note that 68% (n = 66) of participants considered it necessary to reduce AM, but the majority (90.7%, n = 88) stated that raising pigs without antimicrobials is not viable.

Subsequently, when asked about the benefits of using antimicrobials in pig farming, 81.4% (n = 79) of respondents indicated that these medications help prevent diseases, ensure the farm's productivity (89.7%, n = 87) and have a positive impact on pig welfare (87.6%).

Thus, based on the data obtained, the lack of consensus among participants regarding the possibility of reducing the use of antimicrobials may reflect different perceptions regarding their benefits and risks. As a result, this divergence indicates the need for educational initiatives to raise awareness among producers involved in pig farming. According to Albernaz-Gonçalves, Olmos and Hötzel (2021), pig farmers perceive more advantages than risks in the use of AM, considering their cost in relation to their effectiveness in pig production. Therefore, regarding the agreement that is necessary to reduce the use of antimicrobials in pig production, this may be related to concerns about antimicrobial resistance. On the other hand, the belief that is impossible to raise pigs without them may reflect economic concerns, given the industry's dependence on these drugs to maintain the health and growth of animals. This is confirmed by the fact that most interviewees recognize AM as essential for preventing diseases and maintaining pig productivity and welfare.

Considering the above, a similar understanding was observed by Lekagul *et al*. (2021) in a qualitative study conducted in Thailand, where all pig farmers interviewed considered the use of antimicrobials essential for maintaining animal health, as well as being fundamental for controlling and preventing diseases. Many of these producers also indicated that antimicrobials are an accessible solution for reducing animal mortality. Likewise, in a survey conducted in Brazil, Albernaz-Gonçalves, Olmos, and Hötzel (2021) investigated the reasons for the use and overuse of antibiotics on pig farms. They found that producers view these drugs as the primary tool for preventing infections, considering them indispensable in pig farming. Thus, although many farmers recognize the high cost of AM, they see the investment as necessary to avoid significant losses from disease or increased mortality rates.

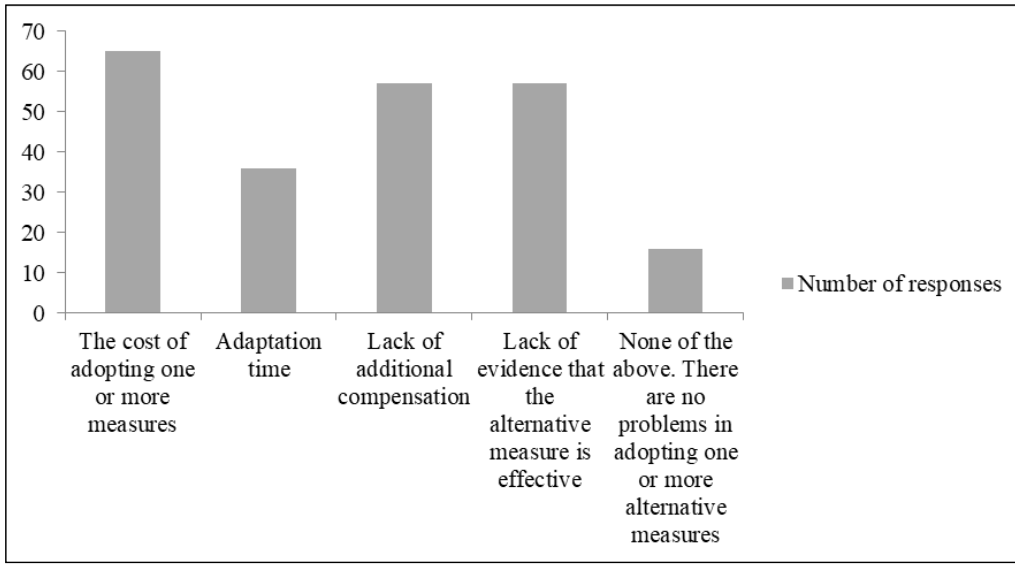
Subsequently, when asked about alternatives to help reduce the use of antimicrobials, pig farmers showed divided opinions: while 52.6% (n = 51) of them were aware of one or more alternatives, 47.7% (n = 46) were unaware of any methods, such as biosecurity (external and internal), good agricultural practices, probiotics and vaccination.

Therefore, after explaining each of the previously mentioned alternatives, participants were asked whether they willing to adopt them and which of the alternatives presented they preferred. As a result, 64.9% (n = 63) of the producers expressed a willingness to use all alternatives, 21.6% (n = 21) said they would not adopt any, and 13.4% (n = 13) indicated that they might use them. Among the proposed measures, good agricultural practices were the most widely accepted, followed by internal and external biosecurity. Overall, all the alternatives presented were well-received.

In addition, to better understand the limiting factors or barriers to adopting alternative measures that could reduce antimicrobial use in pig farming, the respondents were asked about the obstacles they identified among the following options available in the questionnaire: the cost of adopting one or more measures, the adaptation time, the absence of extra compensation, or lack of evidence proving the effectiveness of the alternative

measure. The results showed that the cost of adopting one or more measures was cited by 67% (n = 65) of participants, followed by the lack of extra compensation (58.8%, n = 57) and the absence of proof of the effectiveness of the alternative measures (58.8%, n = 57) as the main challenges mentioned (Figure 4).

Figure 4. Distribution of responses regarding limiting factors for the adoption of alternatives measures aimed at reducing the use of antimicrobials



Consequently, the interviewees' knowledge about alternatives to reduce antimicrobial use revealed the need for further clarification, as many were still unaware of existing methods. After receiving explanations, most were willing to consider alternatives, although some still demonstrated reluctance or indecision, emphasizing the importance of more targeted communication and persuasion strategies. Albernaz-Gonçalvez, Olmos and Hötzel (2021) highlight those changes in routine practices, especially when they involve costs and hard-to-observe outcomes, such as antimicrobial resistance, are challenging. Alternatives like vaccination and reducing population density, despite being more expensive or labor-intensive, may be necessary to avoid the use of AM to compensate for inadequate management practices.

The main limiting factors cited by participants for adopting these alternatives were cost, lack of additional remuneration, and lack of evidence regarding their effectiveness. Studies such as De Marco (2021) show that adapting farms to meet minimum biosecurity standards can be expensive, with isolation fencing representing the highest cost. Furthermore, Albernaz-Gonçalves, Olmos and Hötzel (2021) reported that, despite producers' awareness of the need for improvements, many still view biosecurity practices as expensive and laborious.

Continuing, the last but one block of questions focused on producers' knowledge about the risks of using AM for animal and human health, as well as consumers' concerns about the use of antimicrobials in pork production. Thus, it was identified that the majority of interviewees (82.5%, n = 80) had already heard of antimicrobial resistance and 94.8% (n = 92) of them believe that the inappropriate use of these drugs can lead to resistant microorganisms or bacteria. In addition, the majority of respondents are also aware of the possibility of AM residues remaining in the meat (80.4%, n = 78), after their use, with the information generally received through technicians from the integrators. However, when participants were asked about the relationship between the use of antimicrobials in animals and resistance in humans, there was a variation in the answers: 42.3% (n = 41) of the pig farmers participating in the study believed in this relationship, 35.1% (n = 34) did not believe, and 22.7% (n = 22) were unsure. Regarding the impacts of these drugs on personal health or that of their family members, the opinions of the interviewees were balanced (51.5% believed so, while 48.5% did not). Moreover, with respect to the perception of consumer concern about antimicrobial use in pigs, 63.9% (n = 62) of the participants believe there is consumer concern, while 34% (n = 33) do not share this opinion.

Additionally, these data reveal interesting information about pig farmers' knowledge of the effects of antimicrobial use in pig production on animal and human health, as well as their perception of pork consumers. In other words, the findings indicate a good level of understanding on the part of producers about the risks of antimicrobial resistance associated with the inappropriate use of AM and their perception of consumers' concerns about the issue.

The results show that the majority of respondents are aware of the risk of antimicrobial residues in meat, attributing this knowledge to the technical guidance they have received. This awareness is crucial to ensure food safety and reduce public health risks. In this way, the study corroborates the findings of Albernaz-Gonçalves, Olmos and Hötzel (2021), who also found that pig farmers recognize these risks. However, there was variation in responses regarding the relationship between antimicrobial use in animals and bacterial resistance in humans, indicating a gap in information. Similarly, the perception of the health impacts on the respondents themselves or their families was divided. Consequently, the findings underscore the need for health education, particularly on the relationship between antimicrobial use in animals and bacterial resistance in humans. In this context, Albernaz-Gonçalves, Olmos and Hötzel (2021) also observed that most pig farmers do not recognize the connection between antimicrobials used in humane and veterinary medicine. This lack of knowledge may increase the risks of occupational transmission of AMR, reinforcing the importance of educating producers about the associated dangers.

In addition, the survey also revealed producers' opinions on consumer perceptions of the use of AM in pig farming. Accordingly, the majority of pig farmers (63.9%) believe that consumers consider this issue to be significant, a finding that aligns with several studies demonstrating growing consumer interest in food production practices, including the use of medications in animals. For instance, research by Hötzel and Vandresen (2023) indicates that Brazilians associate intensive production systems with the use of pesticides, hormones and antibiotics, while organic and free-range systems are perceived as healthier

and more natural. Furthermore, a survey conducted by Castro (2019) in southern Brazil showed that 61.5% of respondents believed that meat contained contaminant residues, mainly antibiotics and hormones. Moreover, 72% of participants would be willing to pay an additional amount of between 20% and 50% for products with welfare seals, antibiotic-free or organic. In this context, it is important to clarify that 88% of these participants were pork consumers.

In light of the results obtained, it is necessary to pay attention to those respondents who do not believe that consumers are concerned about the use of antimicrobials in pig farming (34%, n = 33). For this group, communication strategies focused on clarifying consumer concerns and promoting more appropriate production practices could be useful. In this sense, the study by Albernaz-Gonçalves, Olmos and Hötzel (2021) also identified that 53% of pig farmers underestimated the role of Brazilian consumers in changing the use of antimicrobials, considering them to be poorly informed or uninterested in production practices. These producers believe that consumers prioritize more the pork sensory quality and price. This disparity between the producers' view and the results of consumer surveys indicates the need for greater alignment of information between these two groups.

The last block of questions sought to assess the producers' knowledge about the prudent use of AM and public policies related to the topic. As a result, of the interviewees, 76.3% (n = 74) stated that they were familiar with the concept of prudent use of antimicrobials. Therefore, they were then asked to describe what this meant to them, with the responses being grouped into the following categories: use of antimicrobials only when necessary (54%, n = 40); respect to the prescribed dosage, duration of treatment and withdrawal period (45%, n = 33); use as prescribed by the veterinarian (20%, n = 15) and use only associated with good management, vaccination and hygiene practices (3%, n = 2). It is worth noting that 16% (n = 12) of the participants mentioned multiple of these practices in their responses, while 4% (n = 3) said they could not explain the concept, despite having heard about it.

In relation to public policies, 59.8% (n = 58) of the participating producers reported having heard about or were aware of legislation that prohibits the use of certain antimicrobials in pig feed. At the same time, for 68% (n = 66) of them, these legal restrictions can imply financial losses for the pork industry.

Therefore, the analysis reveals that most pig farmers have some level of familiarity with the topic of responsible use of AM in animal production. This is evidenced by the fact that the responses of participating producers align with the guidelines of the global awareness campaign on the rational use of antimicrobials, known as the rule of five "only". This campaign, promoted by the World Organization for Animal Health (WOAH), was aimed at veterinarians and the general public, with translation and dissemination carried out by the Ministry of Agriculture and Livestock (MAPA) in Brazil.

However, although MAPA promotes educational campaigns, there is still a significant portion of pig farmers (40.2%, n = 39) who are unaware of legislation that prohibits the use of certain antimicrobials in feed. This highlights the need to improve communication and reach of this information among producers.

In addition, many pig farmers expressed concern that restrictive public policies could negatively impact the pork industry. The study by Albernaz-Gonçalves, Olmos and Hötzel (2021) corroborates this view, revealing that 63% of the producers interviewed have a negative attitude towards the restriction of the use of veterinary antimicrobials, considering the economic, health and cultural implications. The difficulties in monitoring these laws were also mentioned as a challenge for the effective control of the use of antimicrobials.

Based on above, commercial pig producers in Rio Grande do Sul require appropriate guidance to promote greater engagement with sustainable and efficient practices. To overcome challenges related to production costs, lack of additional remuneration and the need to demonstrate the effectiveness of alternatives to antimicrobial use, an effective strategy is to share successful case studies among producers. In addition, veterinarians should provide guidance that supports both improved economic outcomes and the reduction of risks associated with antimicrobial resistance and food residues (Vasquez *et al.*, 2019).

Caldas (2023) adds that the impact of pursuing prudent antimicrobial use on production costs and herd health can be either positive or negative, depending on how well each producer, farm, or company is prepared to meet this goal. Therefore, thorough planning across all stages of the production chain, including the adequate training of stakeholders, their commitment to the implementation of good practices, the adoption of tailored vaccination programs, the maintenance of effective biosecurity measures, and solid management, plays a crucial role in the success of this transition.

4 CONCLUSION

Commercial farmers in Rio Grande do Sul possess some knowledge about the prudent use of antimicrobials in pig farming, but significant gaps remain. The survey highlights positive aspects, such as the technical assistance provided to all participating farmers by integrators, which offers guidance on the selection and dosage of antimicrobials, while also raising awareness about bacterial resistance and the presence of residues in meat. In addition, most of the pig farmers interviewed expressed willingness to adopt alternatives aimed at reducing the use of antimicrobials in pig production, which may be a result of the influence of technical guidance provided by integrators, as well as the recognition of the importance of these practices for consumers.

However, several weakness were also identified, including the lack of consensus on the feasibility of significantly reducing antimicrobial use and limited knowledge of the alternatives available to assist in this reduction. Key obstacles, such as costs, lack of additional remuneration and doubts about the effectiveness of these alternatives, were frequently mentioned. Divergences in understanding the impact of antimicrobial use on human health suggest that information has not been sufficiently disseminated. Overcoming these barriers will require the implementation of health education strategies and public policies that enhance producers' knowledge and awareness, promoting practices that safeguard the effectiveness of antimicrobials and strengthen biosecurity on pig farms. Additionally, it is essential to address economic challenges by providing guidance on economically viable alternatives to antimicrobial use and sharing successful case studies to encourage the

adoption of sustainable practices. This will contribute to the long-term sustainability of pig farming while reducing the risks associated with antimicrobial resistance.

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