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Constraints to and Prospects for Sustainable Livestock Sector Practices in Argentina with Emphasis on Antimicrobial Usage

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SOUTH CENTRE

RESEARCH PAPER

202

CONSTRAINTS TO AND PROSPECTS FOR SUSTAINABLE LIVESTOCK SECTOR PRACTICES IN ARGENTINA WITH EMPHASIS ON ANTIMICROBIAL USAGE

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ABSTRACT

Antimicrobial resistance (AMR) is a top threat for global health and development as it has the potential to become the next pandemic. Agriculture roughly accounts for three-quarters of all the antimicrobial usage. Modern animal husbandry systems use antimicrobials for disease prevention and growth promotion. Regulations and restrictions regarding antimicrobial use in agriculture vary across the regions of the world. This paper explores the situation of the Argentina livestock sector with regard to antimicrobial use. Argentina is renowned as a global food producer, notably for its grain and livestock production potential. This paper analyzes the constraints to and prospects for transitioning towards a more sustainable livestock farming production in Argentina by relying less on antimicrobials and without compromising productivity. The livestock sector in Argentina has embarked on the intensification of farming, especially beef farming, in the last thirty years. Farming intensification generally requires the use of greater quantities of antibiotics. Alternative sustainable intensification is necessary to overcome antimicrobial overuse. Various factors, including economic, social, and cultural, shape consumption patterns. The Argentine farming sector needs to focus on these context-specific situations, which will drive animal food production.

La resistencia a los antimicrobianos (RAM) es una de las principales amenazas para la salud mundial y el desarrollo, ya que puede convertirse en la próxima pandemia. La agricultura representa aproximadamente las tres cuartas partes de todo el uso de antimicrobianos. Los sistemas modernos de cría de animales utilizan antimicrobianos para prevenir enfermedades y promover el crecimiento. Las normativas y restricciones relativas a al uso de antimicrobianos en la agricultura varían según las regiones del mundo. En este artículo se analiza la situación del sector ganadero argentino con respecto al uso de antimicrobianos. Argentina es un país reconocido como productor mundial de alimentos, sobre todo por su potencial de producción de cereales y ganado. Este estudio analiza las limitaciones y las perspectivas de transición hacia una producción ganadera más sostenible en Argentina, dependiendo menos del uso de antimicrobianos y sin comprometer la productividad. En los últimos treinta años, el sector ganadero argentino se ha embarcado en un proceso de intensificación de la ganadería, especialmente la de vacuno. La intensificación de la ganadería requiere generalmente el uso de mayores cantidades de antimicrobianos. Es necesaria una intensificación sostenible alternativa para superar el uso excesivo de estos. Diversos factores, entre ellos económicos, sociales y culturales, configuran los patrones de consumo. El sector agropecuario argentino debe centrarse en estas situaciones específicas del contexto, que impulsarán la producción de alimentos de origen animal.

La résistance aux antimicrobiens (RAM) est une menace majeure pour la santé et le développement dans le monde, car elle pourrait devenir la prochaine pandémie. L'agriculture représente environ les trois quarts de l'utilisation totale d'antimicrobiens. Les systèmes modernes d'élevage utilisent des antimicrobiens pour prévenir les maladies et stimuler la croissance. Les réglementations et les restrictions concernant l' utilisation des antimicrobiens dans l'agriculture varient d'une région du monde à l'autre. Le présent Document de recherche examine la situation dans le secteur de l'élevage en Argentine en ce qui concerne l' utilisation d'antimicrobiens. L'Argentine est reconnue comme un producteur alimentaire mondial, notamment pour son potentiel de production céréalière et animalière. Cette étude analyse les contraintes et les perspectives de transition vers une production animale plus durable en Argentine, en s'appuyant moins sur l' utilisation des antimicrobiens mais sans compromettre la productivité. Le secteur de l'élevage en Argentine s'est lancé dans l'intensification de l'agriculture, en particulier de l'élevage bovin, au cours des trente dernières années.

L'intensification de l'élevage nécessite généralement l'utilisation de plus grandes quantités d'antibiotiques. Une intensification alternative et durable est nécessaire pour remédier à la surutilisation des antimicrobiens. Divers facteurs, notamment économiques, sociaux et culturels, façonnent les modes de consommation. Le secteur agricole argentin doit se concentrer sur ces situations contextuelles spécifiques, qui détermineront la production d'aliments pour animaux.

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1. INTRODUCTION

The sharp increase in human population, expected to be 9.7 billion people by 2050, has set the alarm to produce food for two more billion people and to end hunger and unhealthy diets affecting millions of people.[2] Intensification of livestock farming systems has been a strategy to increase yields per land area and produce uniform produce at relatively low prices. Intensive farming systems are high external input systems; they require labor, machinery technologies, expertise knowledge, concentrates, and chemicals. This intensification has detrimental effects on animals, humans, and the environment. An important input in intensive farming systems is antibiotics. Antibiotics are widely used as growth promoters or for prophylaxis. Healthy food producing animals receive in their water and or feed sub doses of antibiotics; a mass drug administration which is the main difference between the use of antibiotics in humans and animals.

Antimicrobial usage (AMU) is a main driver of antimicrobial resistance (AMR) in animals and in humans.[3] AMR is a global health concern and burden. Deaths related to bacterial AMR in 2019 rounded 6 million people in 2019.[4] AMR also threatens modern human and veterinary medicine based on the use of antibiotics to treat human and animal illnesses. It is a concern for both human and veterinary medicine, because almost all antibiotics used for humans are also used in veterinary medicine. Moreover, resistant bacteria found in animals can be spread to humans through various ways, such as food consumption, animal handling, food cross-contamination and via the environment. The AMR phenomenon is a clear example of the interdependence of animals, humans, and the environment in what is called “One Health”. While the One Health concept originated a bit more than a century ago, it has a new revival and has been taken up by UN organizations in their agendas and strategies.[5]

Several studies have shown that reducing the use of antimicrobials in agriculture has a favorable impact on levels of antimicrobial resistance, highlighting the importance of finding ways to reduce reliance on antimicrobials in agriculture. The relationship between AMU and AMR has received comparatively greater attention in northern European countries, especially in Scandinavia, where the ban on antibiotics critical to human medicine began more than 20 years ago. The importance of preserving antimicrobials for human and animal populations has permeated society. For example, consumers might be willing to pay for food produced without antimicrobials. These niche markets are an excellent incentive for reducing the dependence on antibiotics to produce animal food.

This paper explores the constraints and opportunities for reducing AMU in the livestock sector of Argentina by offering an analysis of the extent to which the industry is trying to transition to a more sustainable production while maintaining productivity.

First, the paper describes the state of the livestock sector and the market. Next, drivers of overuse or misuse of antibiotics and evidence of their link to human health are analyzed. Finally, the paper summarizes data on retail supermarket chains to detect consumer preferences or willingness to pay for high-quality meat (i.e., meat produced without antibiotics). It maps the actors in the supply chain, such as the main companies and their product destinations.

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[2] FAO Global agriculture towards 2050, High Level Expert Forum - How to Feed the World in 2050 (Rome, 2009) https://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf .

[3] World Health Organization. *The evolving threat of antimicrobial resistance: Options for action.* (2012) ISBN 978 92 4 150318 https://www.afro.who.int/sites/default/files/2017-06/9789241503181_eng.pdf.

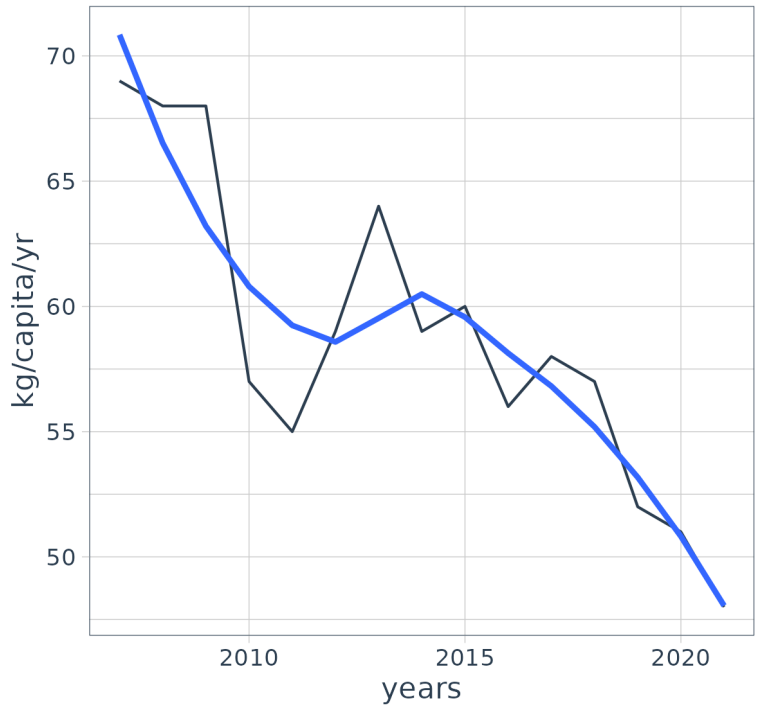
[4] Murray, Christopher JL, et al. *Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis.* The Lancet 399.10325 (2022): 629-655. https://doi.org/10.1016/S0140-6736(21)02724-0.

[5] FAO, OIE and WHO. The Tripartite’s Commitment Providing multi-sectoral, collaborative leadership in addressing health challenges (October 2017) https://www.woah.org/app/uploads/2018/05/tripartite-2017.pdf.

2. The Livestock Industry in Argentina

The livestock industry in Argentina is a significant and integral part of the country's economy and culture. Argentina is known for its vast and diverse agricultural landscapes, and livestock farming plays a crucial role in its agricultural sector. The bovine, pork, and poultry subsectors (the most notable by numbers) together make 30% of the gross production value of the agricultural sector and employ over 400 thousand people.[6] The most significant of all livestock sectors by consumption per capita per year is beef. Figure 1 shows consumption per capita has been declining, yet Argentina remains the country with the highest consumption of beef per capita.

Figure 1
Beef consumption in Argentina



Source: own elaboration with INDEC data https://www.indec.gob.ar/

The Beef Sector

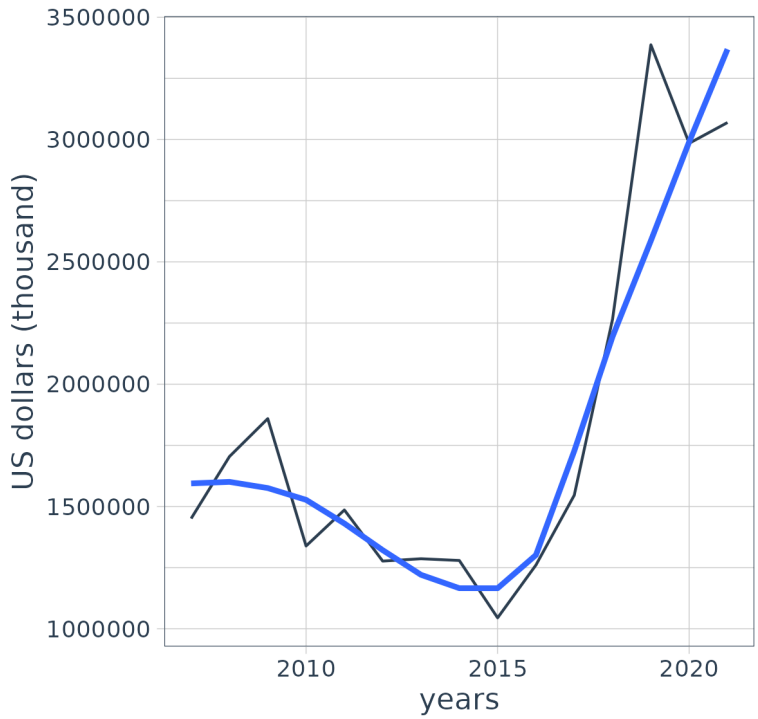
The beef sector of Argentina originated in the 16th century, the first cattle came from the Viceroyalty of Peru during the Spanish colonization. The Spanish culture of cattle ranching, together with well-adapted Creole or Criollo cattle, became the cornerstones of the Argentine beef industry. With the vast, fertile pasture land and mild climate, cattle farming became a prosperous activity.[7] By the mid-19th century, Argentina had in its pastures British cattle breeds (Shorthorn, Hereford, and Aberdeen Angus), and it became the most important beef-

[6] Bolsa de Comercio del Rosario. *La importancia de la ganadería para la economía argentina* (2021) https://www.bcr.com.ar/es/mercados/investigacion-y-desarrollo/informativo-semanal/noticias-informativo-semanal/la-48.
[7] Jonathan C. Brown *A Nineteenth-Century Argentine Cattle Empire Agricultural* History Vol. 52, No. 1 (1978), pp. 160-178 https://www.jstor.org/stable/3742956.

producing country with an export-oriented focus. Today, the cultural value of traditional beef farming is rooted in the "*gaucho"* figure, a skilled cowboy that emerged during the colonial period. The Gauchos played a key role in the success of traditional extensive grazing beef farming and shaped the heartland (the Pampeana region) of Argentine beef farming. To date, Argentina's culture is tied to beef consumption in what is known as "*asado"*, a unique way of eating grilled beef with friends and family members.

According to the USDA report,[8] Argentina's cattle population was 53 million in 2021. This figure is far higher than the numbers reported by the agricultural census. According to the agricultural census, in 2018, there were 40.5 million cattle heads in 130 million cattle farms.[9] Compared to the previous census from 2002, the cattle population has declined by almost one-fifth and the number of farms by one-third.[10] USDA projects disinvestment, marginally reduced herd size, and cattle slaughter.[11] Argentina is one of the top exporters of beef in the world.[12] Beef is also an important source of foreign currency and shows a growing trend (Figure 2). Beef demand from China is a main driver of beef exports. The Argentine Government has banned exports in the past as a means of controlling inflation within the country.[13]

Figure 2
Yearly Argentina meat export sales in US dollars



Source: own elaboration with INDEC data https://www.indec.gob.ar/

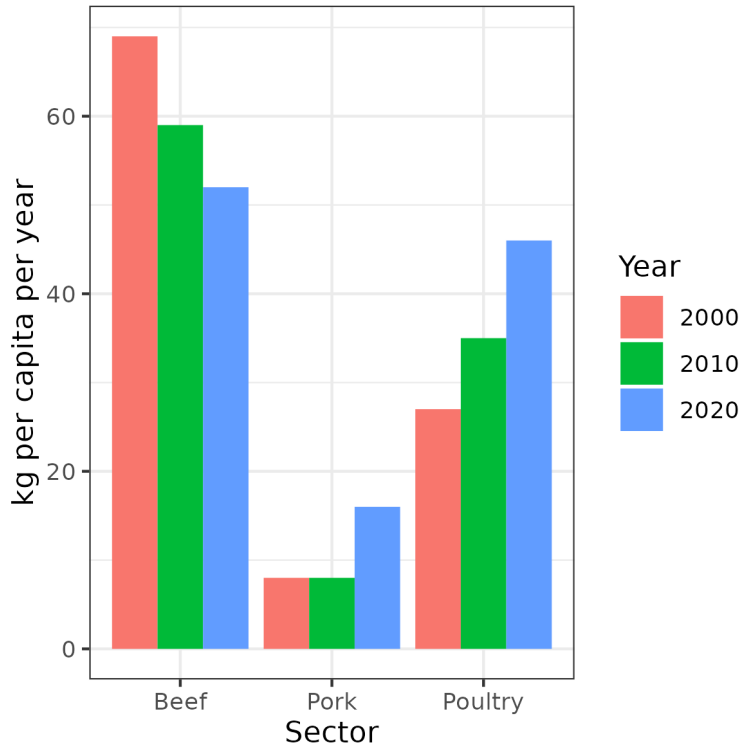
[8] USDA *Livestock and Products Annual: country Argentina* (2022) https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Livestock%20and%20Products%20Annual_Buenos%20Aires_Argentina_AR2022-0015.pdf.
[9] INDEC. Censo Nacional Agropecuario (2018) https://cna2018.indec.gob.ar/.
[10] Ibid.
[11] USDA *Livestock and Products Annual: country Argentina* (2022) https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?fileName=Livestock%20and%20Products%20Annual_Buenos%20Aires_Argentina_AR2022-0015.pdf.
[12] Ibid.
[13] Steiger, Carlos. *Modern beef production in Brazil and Argentina*. Choices 21, no. 2 (2006): 105-110.

An important amount of beef production in Argentina takes place now in what is called the feedlot system. The feedlot system is an intensive farming method dependent on external inputs. Intensive farming is common for finishing or fattening cattle. Cattle receive grain-rich diets, and antimicrobials are an important input in fattening systems to increase weight gain and prevent and treat diseases, as cattle by nature eat roughage. Feedlots are the result of competing land and were introduced 30 years ago as cropping displaced beef farming from high, fertile land. While cow-calf farming in a graze-fed system has shown more financial stability, the feedlot operation had losses due to the 50 per cent increase in grain prices (i.e., maize) in 2020.

Poultry and Pork Sectors

Pigs were brought in Argentina at the same time as cattle, but the pork farming is minor when compared to beef farming. Poultry husbandry history in Argentina is much more recent, as the first chickens arrived in the 19th century. Poultry farming, however, quickly turned into a complementary livelihood strategy for people's livelihoods. The poultry and pork sectors are also prominent on their own, as consumption is becoming more popular and exports to Asia, Africa, and Latin America are the main destinations, with predictions that they will increase. Likewise, intensive-industrial-scale pork and poultry systems are common in Argentina. Currently, poultry and pork meat consumption is starting to be more popular. In the last twenty years, poultry meat consumption per capita has doubled (see Figure 3). There is a downward trend in beef meat consumption in contrast to poultry and pork meat.

Figure 3
Consumption of main meat types, kg per year in three time points, 2000, 2010, and 2020

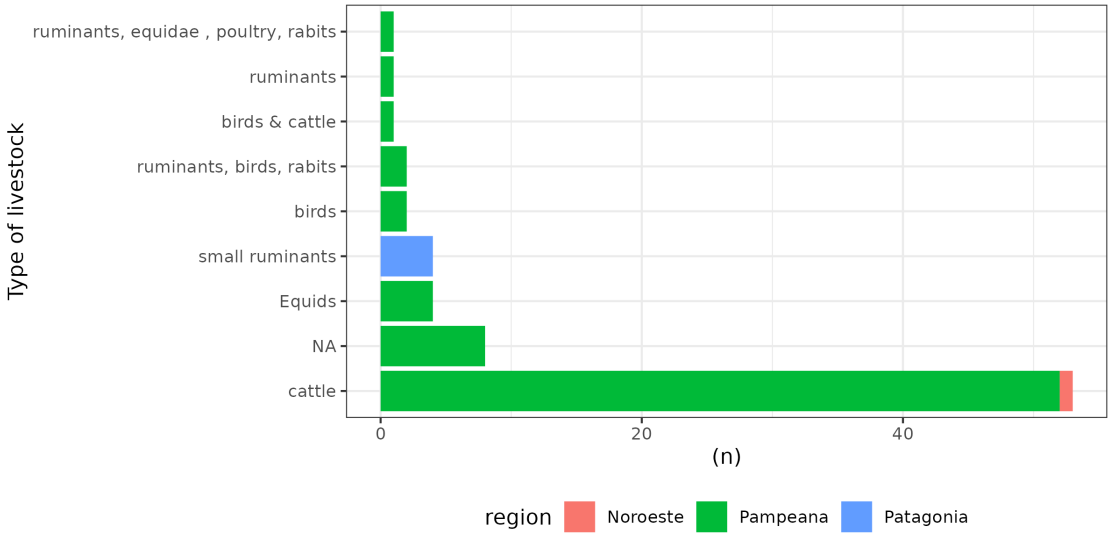


Source: own elaboration from USDA 2021 report https://fas.usda.gov/data/argentina-livestock-and-products-annual-5

3. THE LIVESTOCK EXPORT MARKET OF ARGENTINA

Argentina has been a leading player in the world market especially with beef exports. This would not be possible without, among other things, Argentinean infrastructure. Figure 4 shows the number of slaughter houses with export certification. Most of the facilities are oriented toward cattle and are located in the Pampeana Region. Export certifications are granted by SENASA, the National Food Safety and Quality Service (in Spanish: Servicio Nacional de Sanidad y Calidad Agroalimentaria – SENASA).

Figure 4
Slaughter facilities with export certification

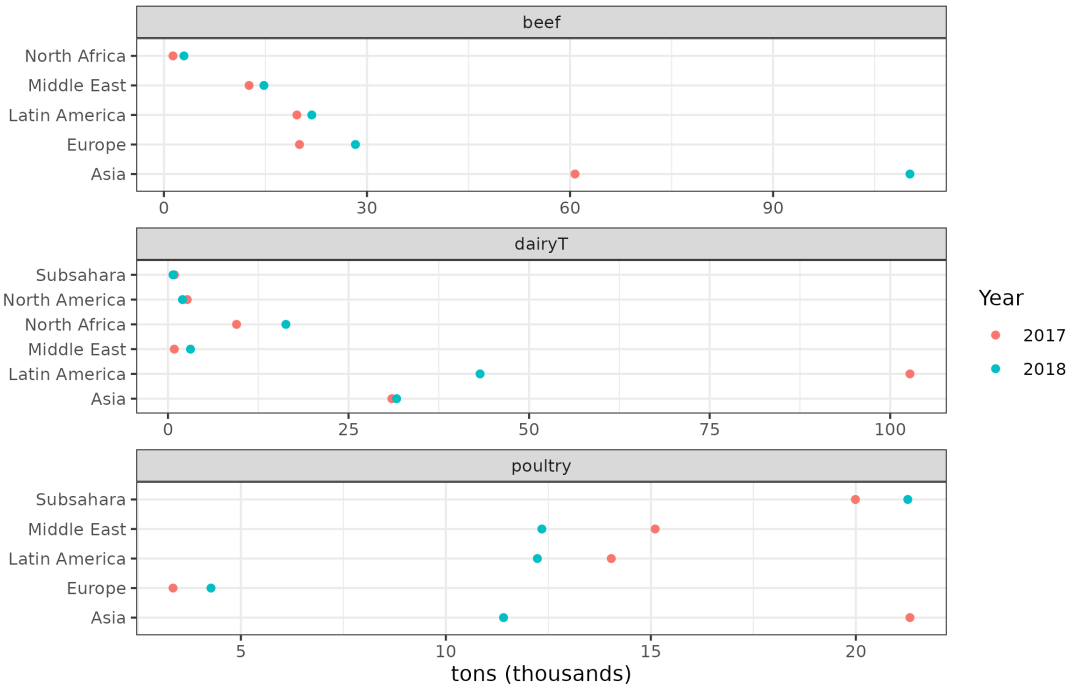


Source: own elaboration data from SENASA

Figure 5 shows Argentina's beef, dairy, and poultry exports in 2017 and 2018. With regards to beef, Asia (China and Russia) is the most important export destination by volume, and Europe is second. The European market is especially attractive to Argentina traders and producers because of a special trade agreement called the Hilton Quota, very attractive for farmers. The Hilton Quota comprises a zero tariff for exporting high-quality beef cuts from graze-fed animals to the European Union. This allows Argentina to export 29,389 tons of beef and 200 tons of buffalo meat annually.[14] The Hilton Quota is filled with high value chilled cuts. In 2020, SENASA made a drastic cut to the list of eligible ranches (grazing systems), reducing the number from 12,000 to 5,000.

[14] Ministerio de Economía de Argentina, Secretaría de Agronomía y Pesca. *Cuota Hiton.* https://www.magyp.gob.ar/sitio/areas/ss_mercados_agropecuarios/cuotas/_archivos/_union_europea/_hilton.php.

Figure 5
Exportation of beef, dairy, and poultry in 2017 and 2018 (Thousands of tons were exported in the first eight of each year).



Source: own elaboration with data from IPAC

Beef exports to Latin America are also relevant. Chile is a main destination and they keep opening markets in other countries like Mexico. Argentina has special beef certifications (Halal and Kosher), which are sold in the Middle East. A great volume of dairy produce is traded within Latin America, especially to Brazil. Asia is the second important destination for dairy products, and China is the main importer. Poultry is the second most exported meat, and Sub Saharan African countries and Asia are the main destinations.

4. DRIVERS OF OVERUSE OR MISUSE OF ANTIBIOTICS IN THE LIVESTOCK INDUSTRY AND EVIDENCE OF THEIR LINK TO HUMAN HEALTH

The overuse and misuse of antibiotics in the livestock sector on a global scale raises a serious threat due to the risk of AMR, which has consequences for the health of animals, humans and the environment. A number of key drivers contribute to this issue, and scientific evidence shows the link between antibiotic use in the livestock sector and the risks of AMR spreading. The following sections describe some key drivers of potential overuse and misuse in Argentina.

Over-the-Counter Sales of Antibiotics

Farmers have literally free access to almost any antibiotic. Antibiotics are often available over the counter, and veterinary oversight is not required.[15]

> "…The producer comes and … has a sick animal, [Our] employee provides an Oxi[tetracycline] [LA bottle], or when suspects a respiratory issue, prescribes Tilmicosin … it is a small producer who has not got a vet … it is dispensed as if it were a pharmacy" (vet pharmacy).[16]

Sometimes they are obtained by simply skyping the veterinarian.

> "… today we have a marketing system very similar to what agrochemicals is … it's no longer happening that the vet goes to the field to see the cows" (vet pharmacy)[17]

Assortment of Antibiotics

The assortment of antibiotics is prominent in Argentina.[18] Figure 6 shows the number of different brands of each antibiotic class. The greatest classes of antibiotics are tetracyclines, cephalosporins, and quinolones. Ionophors and macrolides have fewer brands. This does not mean that ionophors such as monensin or macrolides such as tilmicosine are less used in farming. In fact, ionophors, tetracyclines, and macrolides are the most used in quantity (mg per population correction unit) by the beef farming sector.

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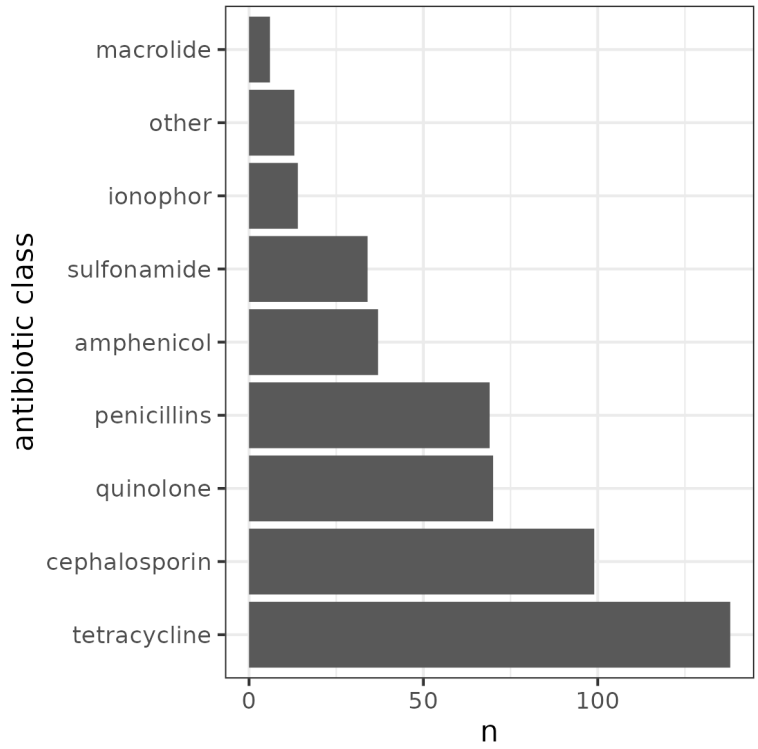
[15] Oseguera Montiel, D et al., Antibiotic supply chain map of the Argentinian beef industry: A mixed methods approach (qualitative and quantitative methods). 2023 International ISESSAH Conference: Understanding stakeholder behaviour and socio-economic implications of practices and policies of animal health Helsinki, Finland. https://www.isessah.com/conference-2023/.

[16] Ibid.

[17] Ibid.

[18] SENASA. *Consulta de los Productos de Fármacos y Productos Veterinarios* https://aps2.senasa.gov.ar/adt/pages/public/farmacos/consultaProductosFarmacos.faces

Figure 6
Number of antibiotic brands (480) offered in the Argentine veterinary market, grouped by class



Source: own elaboration with data from SENASA

The large assortment is also a reflection of the size of the pharmaceutical industry in Argentina. A powerful sector that influences antibiotic usage in the livestock sector. Manufacturers can be direct points of sale for prominent farmers or for the most integrated or vertical pig and poultry sectors.[19]

A real issue is the labeling, which could be inappropriate. For example, amphenicols should not be used in lay hens because of the risk of residuals in eggs.[20] Antibiotic brands, however, do recommend using the product on birds, whether they are lay hens or broilers.[21]

Prophylactic use of Antibiotics in Farming

The prophylactic use of antibiotics is prominent in Argentina. Prophylactic use is a normal practice in intensive farming systems, like in the feedlot systems. In the beef sector, farmers use ionophors such as monensin; others used are macrolides and chlortetracycline, which are administered routinely to prevent, among others, acidosis, liver abscess, and pneumonia.

[19] Oseguera Montiel, D et al., Antibiotic supply chain map of the Argentinian beef industry: A mixed methods approach (qualitative and quantitative methods). 2023 International ISESSAH Conference: Understanding stakeholder behaviour and socio-economic implications of practices and policies of animal health Helsinki, Finland. https://www.isessah.com/conference-2023/.
[20] EMA. Committee for Veterinary Medicinal Products. Florfenicol EMEA/MRL/589/99-FINAL (1999) https://www.ema.europa.eu/en/documents/mrl-report/florfenicol-extension-chicken-summary-report-3-committee-veterinary-medicinal-products_en.pdf.
[21] Vademecum OVER. Florfenicol SOLUCIÓN ORAL 10% OVER https://over.com.ar/product/florfenicol-solucion-oral-10-over/.

These are some of the most commonly used antibiotics in beef farming.[22] Monensin can leak into the environment, as it has been found in rivers at high ecotoxicological risk levels.[23]

Farming can also contaminate water bodies for human consumption with harmful bacteria that have resistance genes to antibiotics The authors found *E. coli* isolates with resistant genes to ampicillin and tetracycline, suggesting that these two antimicrobials are widely used in farming in the study area.[24]

Lack of Systemic Surveillance of AMU

As in many other low and middle income countries (LMICs), the quantity of antimicrobials used in the Argentinian livestock sector is unknown. In addition, published information about antimicrobial usage in the livestock sector of Argentina is scant. The use of antimicrobials is estimated by calculating how much was imported and how much was exported. It does not differentiate between how much was used in animals and how much was used in humans.

> And this is as far as we go in Argentina [key expert in the industry].

One of the direct impacts of using antibiotics in farming is human exposure to those antibiotics, as residues are found in animal food products on the market. A study, for example, found in fish samples enrofloxacin, clarithromycin, roxithromycin, doxycycline, and oxytetracycline in 100% of the samples.[25]

One of the problems of human consumption of antibiotics in food is that some antibiotics can be carcinogenic, and there is a risk of developing antibiotic resistant bacteria in human populations.[26]

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[22] González Pereyra, A.V., Pastorino, F.L. y Gil, S.B. *Uso y cuantificación de antimicrobianos en sistemas ganaderos intensivos de producción de carne* (Área: Ciencias Veterinarias. Bloque: Comunicaciones de Investigadores: Medicina veterinaria en el ámbito pecuario y salud pública). IX Jornadas de Investigación. Universidad Juan Agustín Maza. Mendoza, República Argentina. (2020), Revista Jornadas de Investigación, año 11, nº 11. 128 https://repositorio.umaza.edu.ar//handle/00261/2472.

[23] Pérez, D.J., Okada, E., Iturburu, F.G. *et al. Monensin occurrence in surface water and its impact on aquatic biota in a stream of the southeast Pampas, Argentina*. Environ Sci Pollut Res 28, 8530–8538 (2021). https://doi.org/10.1007/s11356-020-11009-2.

[24] M. L. Gambero, M. Blarasin, S. Bettera and J. Giuliano Albo (2018) *Tracing contamination sources through phenotypic characterization of Escherichia coli isolates from surface water and groundwater in an agro-ecosystem,* Hydrological Sciences Journal, 63:8, 1150-1161, https://doi.org/10.1080/02626667.2018.1483582.

[25] Griboff J, Carrizo JC, Bonansea RI, Valdés ME, Wunderlin DA, Amé MV. Multiantibiotic residues in commercial fish from Argentina. The presence of mixtures of antibiotics in edible fish, a challenge to health risk assessment. Food Chem. 2020 Dec 1;332:127380. https://doi.org/10.1016/j.foodchem.2020.127380.

[26] Bacanlı M, Başaran N. Importance of antibiotic residues in animal food. Food Chem Toxicol. 2019 Mar;125:462-466. https://doi.org/10.1016/j.fct.2019.01.033.

5. Argentine Regulation With Regard to Antimicrobial Usage in Livestock

SENASA is the authority that grants permits and controls veterinary drug quality and marketing. It is responsible for banning antimicrobials in animals. For example, in 2019, SENASA banned the production, usage, and trading of colistine for animals. This action followed a recommendation from the World Health Organization to keep Colistine as a reserve antibiotic for human medicine.

Since 2022, Argentina has had a law that aims to prevent and control antimicrobial resistance in humans and animals, following the One Health approach.[27] The main goals of the law are:

- Strengthened surveillance of AMU and AMR.
- Promote the correct use of antimicrobials, and minimize their use.
- Disseminate information about the importance of AMR.
- Encourage digital prescriptions for human medicine.
- Promote the rational use of antimicrobials in animal health and food production.
- Gradual ban of growth promoters.

Besides the government, research institutions are also summing up efforts. For example, to promote a responsible usage of antibiotics among farmers the Center for Research in Veterinary Science and Agriculture (CICVyA) from the National Institute of Agricultural Technology (INTA) is actively involved in communicating the issue of resistance and ways to improve it. This includes direct engagement with producers nationwide and the most representative production chains through talks and advisory services. Additionally, INTA collaborates with laboratories and companies providing services to producers, offering training and discussions to raise awareness about antimicrobial resistance [28]

It is still early to know how effective the law and actions from research institutions have been in reducing AMU in food-producing animals, but the law is innovative at least in Latin America by following the One Health perspective. There are no milestones, however, in the document which could target the reduction for example of growth promoters by measurable targets.

[27] Legislatura de la República de Argentina. Ley de prevención y control de la resistencia a los antimicrobianos. Boletín oficial de la República Argentina. Ley 27680 (2022) https://www.boletinoficial.gob.ar/detalleAviso/primera/270118/20220824.

[28] INTA. Semana de la Concientización sobre la Resistencia Antimicrobiana (RAM) (2023) https://www.argentina.gob.ar/noticias/el-inta-promueve-el-desarrollo-de-productos-alternativos-los-antibioticos-0.

6. TRANSITION TO MORE SUSTAINABLE LIVESTOCK FARMING SYSTEMS IN ARGENTINA

Sustainable farming practices that improve animal health and welfare could have a positive effect on reducing the risk of antimicrobial resistance and improving food safety. In general, farming intensification requires greater amounts of external inputs, such as antibiotics, when compared to extensive farming systems. An example of a more sustainable farming system is organic farming, where antibiotic usage is stricter than conventional farming. In organic farming, antibiotics in animal feed to enhance growth or production are not permitted,[29] which explains why studies showed a lower incidence of antibiotic-resistant bacteria in feces from organic farming when compared to conventional farming.[30]

Argentina occupies second place in the world for dedicated areas (4.4 million ha) for organic agriculture, although a large part of this land area is in the province of Chubut, where, basically, due to the terrain and climatic conditions, land use is restricted to extensive livestock farming [researcher expert in organic farming, personal communication], whereas in the Pampeana region where the land is extremely fertile intensive systems are found, especially the beef feedlot systems and where annually 4.5 million cattle heads are fattened.[31] Nevertheless, a transition to more sustainable livestock farming, like organic animal food produce and graze-fed systems is happening in Argentina already. Argentina counts with domestic agencies certifying organic practices for livestock farming and over a thousand organic farming farms.[32] Organic produce includes red meats and dairy products.The media is playing a role in driving consumer preferences. Beef farming advertisement is also common ; see, for example,[33,34]. A number of factors, including cultural and socio-economic, impact on the transition towards more sustainable livestock farming. Some of these factors and opportunities for the livestock sector are presented next.

Economic Factors

A financial analysis of organic farming showed that financial returns from organic farming can be higher than conventional farming, as the profits can be one-third higher and the benefit/cost ratio can be up to one fifth higher when compared to conventional farming in farms around the globe.[35] One would have thought that the main incentive to shift from conventional farming, for Argentinean farmers, to organic farming was economically driven. A recent study in Argentina however shows that this is not always the case.[36] The authors quote a farmer: “Perhaps the economic result would have been higher [in conventional farming], but the decision was not based on that [to shift to organic].” An important advantage of organic farming

[29] Manual de Normas de Producción Orgánica ECOCERT ARGENTINA SA http://www.argencert.com.ar/sitio/wp-content/uploads/MNARGv02_es_Manual-de-Normas-Orga%CC%81nicas-ECOCERT-ARGENTINA.pdf.
[30] Hoogenboom, L. A. P., et al. *Contaminants and microorganisms in Dutch organic food products: a comparison with conventional products.* Food Additives and Contaminants 25.10 (2008): 1195-1207. https://doi.org/10.1080/02652030802014930.
[31] Servicio Nacional de Sanidad y Calidad Agroalimentaria (Senasa) Nuevo tablero de control de movimientos de ingresos, egresos e índice de reposición en engordes a corral (2022) https://www.argentina.gob.ar/noticias/nuevo-tablero-digital-sobre-movimientos-de-establecimientos-de-engorde-corral.
[32] SENASA Entidades Certificadoras habilitadas por el Senasa 2023 (2023) https://www.argentina.gob.ar/senasa/programas-sanitarios/producci%C3%B3n-organica/entidades-certificadoras
[33] Eco Carnes https://ecocarnes.com/index-es.html.
[34] La Julia https://www.lajuliaorganics.com/.
[35] Crowder, D. W., & Reganold, J. P. (2015). Financial competitiveness of organic agriculture on a global scale. Proceedings of the National Academy of Sciences, 112(24), 7611-7616.
[36] Cabrini, S., & Elustondo, L. (2022). Organic agriculture in Argentina’s Pampas. A case study on Pampa Orgánica Norte farmers. Renewable Agriculture and Food Systems, 37(1), 5-13. doi:10.1017/S1742170521000338.

is risk-aversion. Following the referenced study, for farmers in Argentina, organic production can be less risky when compared to conventional farming. Conventional farming is normally a high-external input system and, for that reason, very sensitive to variations in input prices. And the reason why, for example, feedlot systems in Argentina are on the brink of red numbers.[37]

Environmental and Socio-Cultural Aspects

The spark for sustainable livestock farming in Argentina has been an alliance between two organizations: 1) *Aves Argentinas* (Argentine birds), a non-governmental organization whose members are mainly interested in bird watching; and 2) *Alianza por el Pastizal* (Alliance for Grasslands). The latter is a farmers' organization. Farmers conduct regenerative grazing which is a holistic grazing system aimed at improving biodiversity in their grazing fields and animal well-being by letting livestock graze throughout the production cycle and taking care of the recovery of natural grasslands, forests, water, and wild fauna such as birds.

This has been beneficial for farmers as new market channels are opened for this beef produced in native grazing lands.

> We always fought for a long time with the middlemen. They told us that the color of the fat had a yellow tint, and they lowered the price. That was always the problem. I was convinced, like my dad, that cattle raised on grass with our resources, with the grass from our native area, is what gives us meat that is nutritionally much better than that made in a feedlot system. And we ourselves consume our meat, so we believe that it is an alternative; it is not unpleasant meat; it is very tasty; and yet, we had that problem of marketing, and luckily, we found the people of the alliance for the pasture who were totally the opposite. Greatly valued the pastoral resources. [farmer in Alianza por el Pastizal].[38]

Cycle Beef is one the companies trading this meat which also uses a high tech traceability system.[39]. Cycle Beef meat is now sought by chefs who are knowledgeable on graze-fed beef. This also is trying to recover the tradition that made Argentine beef famous worldwide:

> Cycle Beef works by obtaining meat from this type of producer, starting with this original grass flavor that made us famous in the world. . . that meat on grass, … from the humid pampas [Cycle Beef staff].[40]

In addition, farmers who are part of the *Alianza por el Pastizal* are starting to obtain carbon bonuses which could be an additional benefit for farming and looking after the environment.

> We automatically transfer [the carbon bonuses] to [North American company] so that they can sell them; the fact that they issue you bonds that have no value until you can sell them. [The company] is committed to finding a volunteer to pay for these bonuses. [Farmer selling carbon bonuses].

For the bulk of the population in Argentina the meat choice is still based on the (cheapest) price. [personal communication]

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[37] USDA. Argentina: Livestock and Products Annual (2022) https://fas.usda.gov/data/argentina-livestock-and-products-annual-5.
[38] Interview extract from Bichos Alianza por el pastizal http://tinyurl.com/5y3dm5e9.
[39] World Health Organization, (2012) "The evolving threat of antimicrobial resistance: Options for action." ISBN 978 92 4 1503181 https://www.afro.who.int/sites/default/files/2017-06/9789241503181_eng.pdf.
[40] Interview extract from Bichos Alianza por el pastizal http://tinyurl.com/5y3dm5e9 see also http://tinyurl.com/373m7372 and https://cyclebeef.com/#xl_Inicio.

Challenges and Opportunities to Boost Sustainable Farming Practices

The overuse and misuse of antibiotics in the Argentine livestock industry are driven by multiple factors, ranging from unrestricted access to antibiotics to the prophylactic use of these drugs. Prophylactic usage of antimicrobials is linked to the farming system. Intensive systems routinely use antimicrobials.[41] One of the consequences of AMU are antibiotic residues in animal food products and the development of antibiotic-resistant bacteria in humans which is a serious threat to public health.

The recent law in Argentina to tackle AMU is a promising step towards tackling AMR and AMU from a One Health perspective. How effective this can be in having more control over antimicrobial usage in farming is a main issue. One of the strategies stated is the gradual reduction of antimicrobials as growth promoters, but there are no concrete goals or milestones.

- Direct payments to farmers conducting sustainable farming practices such as reducing antimicrobial usage and/or transitioning into organic farming. Graze-fed or pastoral systems in Argentina have multiple advantages for the health of the ecosystem compared to conventional farming.[42] This opens an opportunity for welfare certification as well, where farmers could benefit from niche markets. Certification related to animal welfare is possible in Argentina.[43].

- The organic farming systems also require information and training.[44] In the case of regenerative grazing, for example, access to electric fencing could help plan the rotation of the grazing areas.

- Support family farming systems to create rich niche markets for their produce. Small-scale farming is often neglected and lacks support to access technologies, information, and niche or better markets for their more ecological produce. Large supermarkets in Argentina do not always have in their catalog organic animal-food produce. Alliances with small producers could be a win-win start.

- Intensive farming needs to implement management practices that have a direct effect on animal health and welfare. These could include: (1) allowing a lower density in their pens, which could reduce the risk. For feedlots, instead of having 10–20 m2 per head, 80 m2 per head could reduce muddy fields that have direct consequences on lameness and consequently on animal health and welfare and on the use of antimicrobials,[45] (2) strong biosecurity measures to prevent outbreaks or disease transmission and, as a consequence, less AMU,[46] (3) promote the use of alternatives to antibiotics, such as probiotics and (4) transit to graze-fed for cattle and free-range (poultry pigs) whenever this allows, so that animal welfare is increased and dependence on antibiotics is reduced. The latter is especially important in feedlot systems where concentrate diets in ruminants force the use of antibiotics such as ionophors (monensin) and chlortetracycline in feed.

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[41] Van Boeckel, Thomas P., et al. *Global trends in antimicrobial use in food animals*. Proceedings of the National Academy of Sciences 112.18 (2015): 5649-5654 https://doi.org/10.1073/pnas.1503141112.

[42] Aves Argentinas ¿Puede la ganadería ayudar a mitigar el calentamiento global? (2019) https://www.avesargentinas.org.ar/noticia/%C2%BFpuede-la-ganader%C3%ADa-ayudar-mitigar-el-calentamiento-global.

[43] IRAM Certificación en Bienestar Animal https://www.iram.org.ar/servicio/bienestar-animal/.

[44] Cabrini, S., & Elustondo, L. (2022). Organic agriculture in Argentina's Pampas. A case study on Pampa Orgánica Norte farmers. Renewable Agriculture and Food Systems, 37(1), 5-13. doi:10.1017/S1742170521000338.

[45] INTA Feedlot ecológico. https://rb.gy/vslcc4.

[46] Antibiotics 2023, 12(5), 893; https://doi.org/10.3390/antibiotics12050893.

- SENASA will need to set up a strategy to measure AMU in farming operations and, ideally, an active AMR surveillance strategy. Having data on AMU could help authorities and farmers set goals for AMU reduction. VETSTAT, the surveillance system implemented in Denmark is a good example on how effective this strategy can be.[47]

- Banning veterinarians and pharmacies from profiting from antibiotic sales could be ideal in Argentina. Denmark has shown how effective that action was in reducing AMU and AMR.[48] This strategy would need to be accompanied by the regulated use of veterinary prescriptions, especially in the case of antibiotics considered as critical by the WHO.[49] Prescriptions will prevent over-the-counter sales. This change would also mean that veterinary pharmacies would have to have a veterinarian responsible for prescribing antibiotics. Any strategy must be adjusted and developed taking into account the socio-economic and cultural context. For example, making the use of veterinary prescriptions mandatory should not prevent farmers from having a first aid kit with antibiotics for emergencies; this is especially important for farmers located in remote locations or far from veterinary services.

[47] H Stege, F Bager, E Jacobsen, A Thougaard, *VETSTAT—the Danish system for surveillance of the veterinary use of drugs for production animals*, Preventive Veterinary Medicine, Volume 57, Issue 3, (2003), pp 105-115. https://doi.org/10.1016/S0167-5877(02)00233-7.
[48] Aarestrup, Frank. *Get pigs off antibiotics*. Nature 486, no. 7404 (2012): 465-466 https://doi.org/10.1038/486465a
[49] OMS Antimicrobianos de importancia crítica para la medicina humana, 6.ª revisión [Critically important antimicrobials for human medicine, 6th revision] ISBN 978-92-4-351552-6.

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