2023

Antimicrobial Use Report

Welsh Lamb and Beef Producers

Contents

Foreword

Welcome to the 3rd annual Welsh Lamb and Beef Producers Antimicrobial Use Report. This report provides detailed analysis of antimicrobial use (AMU) in 6060 beef, sheep and dairy enterprises across Wales in 2023.

The 3rd edition of the Welsh Lamb and Beef Producers (WLBP) Antimicrobial Use Report for 2023 provides a detailed summary of antimicrobial use (AMU) on 2701 beef, 2777 sheep and 582 dairy enterprises across Wales in 2023. Compared to previous reports, this report collates AMU data from a greater coverage of Welsh enterprises, representing AMU in 48% (~62,000) of the total beef stock, 54% (~1.9 million) of the total sheep stock and 57% (~99,000) of the total dairy stock which were assured under the Farm Assured Welsh Livestock (FAWL) Scheme in 2023.

Similar to previous reports, this report presents detailed analysis of AMU by enterprise type, European Medicines Agency (EMA) category, antimicrobial (AM) class and AM administration route. New for this year's report is a detailed look at AM sales throughout the year, split by enterprise type and administration route. This provides insight into the month-on-month variation observed in AM purchasing on farm.

AM sales data utilised by this report were captured and collated via the WLBP AMU Calculator, a novel reporting tool that produces accurate, standardised reports of AMU based on industry-agreed standards (CHAWG, 2020; SHAWG, 2019; ESVAC, 2021). Veterinary surgeons complete AMU calculations for enterprises under their care, which is a requirement for farmers as part of the FAWL assurance scheme. Veterinary surgeons review the AM sales data and assign purchased products to each herd or flock under their care, reporting on disposed quantities where necessary to achieve accurate AMU data.

This report provides valuable insight into how Welsh beef, sheep and dairy sectors are responding to emerging antimicrobial resistance risks and pressures to preserve the effectiveness of antimicrobials through responsible and reduced use. Continuing to publish publicly available AMU reports demonstrates transparency, which has reputational benefits for the Welsh industry through building consumer and wider industry trust and confidence in these food-producing sectors.

Whilst these AMU reports illustrate average trends in AMU in the Welsh beef, sheep and dairy sectors, currently, it is not possible to provide evidence of a change in AMU year-on-year. As a different pool of members contribute to each years' report, it would be erroneous to compare the data collected between years, as contributing farms might vary considerably in enterprise demographics and type between reports. Analysis of trends over multiple years is likely to become possible in the future as members are required to annually report AMU as part of the FAWL assurance scheme. Readers are therefore cautioned to consider these caveats if comparing analysis presented in 2021, 2022 and 2023 reports.

Contribution

This report and all supporting analyses were commissioned by WLBP and conducted independently by researchers at Bristol Veterinary School, University of Bristol, UK.

Analysis and report writing: Dr Caroline Best
Consultation: Dr Lucy Vass, Professor Kristen Reyher, Professor Andrew Dowsey, Dr Judy Bettridge, Mr Elliot Stanton

WLBP's work on AMU forms an integral part of the award-winning **Arwain DGC** (Defnydd Gwrthficrobaidd Cyfrifol / Responsible Antimicrobial Use) programme, which is funded by the Welsh Government and led by Mentera.

For more information on the work of Arwain DGC, please go to:
https://rhaglenni.mentera.cymru/arwaindgc/en/home/

Contact

To find out more about the WLBP AMU Calculator or for any questions on this report, please visit www.wlbp.co.uk or contact us:

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2023 AMU Report – at a glance

Beef
2701
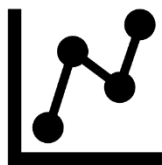enterprises

2.3 mg/kg
Median

Sheep
2777
enterprises

4.6 mg/kg
Median

Dairy
582
enterprises

9.3 mg/kg
Median

Enterprises linked to:
58
veterinary practices

Seasonal peaks in antimicrobial sales observed

Highest 25% of antimicrobial users contributed:

77% 72% 76%
of the total AMU (mg/kg)

Injectables accounted for:
>75%
of total antimicrobial mass used

<1%
of total antimicrobial mass were EMA Category B

Intramammary use

24%
dairy cows treated with **dry cow** tubes

18%
dairy cows treated with **lactating cow** tubes

Top classes used:
Tetracyclines
Aminoglycosides
Aminopenicillins
Penicillins

AMU by enterprise type

AMU in 2023 was calculated for 2701 beef, 2777 sheep and 582 dairy enterprises across Wales using data submitted via the WLBP AMU Calculator. On average, beef enterprises had the lowest AMU and dairy enterprises had the highest AMU out of these three sectors.

AMU data was captured from 2701 beef, 2777 sheep and 582 dairy enterprises for the 2023 calendar year (1st January to 31st December). Compared to the 2022 dataset, this represents an increase of over 7% of beef and 11% of sheep enterprises recording data via the AMU Calculator, and a much larger increase of 35% of dairy enterprises. Since 2021, there has been a consistent climb in numbers of beef, sheep and dairy enterprises actively using the AMU Calculator by 160%, 135% and 100%, respectively. Only 349 enterprises (or 6% of the total enterprises) in the 2023 dataset also had AMU data for 2022 and 2021. Therefore, the 2023 AMU Report findings cannot be directly compared to 2022 or 2021 AMU Report findings.

Similar to patterns reported in the 2022 and 2021 datasets, median AMU in 2023 was found to be the highest in dairy (9.3 mg/kg*) and lowest in beef (2.3 mg/kg*). Sheep fell between these, with a median AMU of 4.6 mg/kg[†] (Figure 1). See the supplementary information for the full methodology used to calculate AMU and why the median is chosen as an averaging method.

Again, consistent with the 2021 and 2022 datasets, there was considerable variation in AMU mg/kg between individual enterprises in 2023. Here, the highest users were responsible for a large proportion of total use. Figure 1 shows the distribution of AMU, with the two averages, median and mean, indicated to illustrate the effect of outliers (e.g. enterprises with very high AMU; see supplementary information on reporting average values). The highest 25% of AM users in beef, sheep and dairy enterprises contributed 77%, 72% and 76% of the total AMU in each sector, respectively.

	Beef	Sheep	Dairy
◆ Mean mg/kg	4.9	7.5	11.9
— Median mg/kg	2.3	4.6	9.3
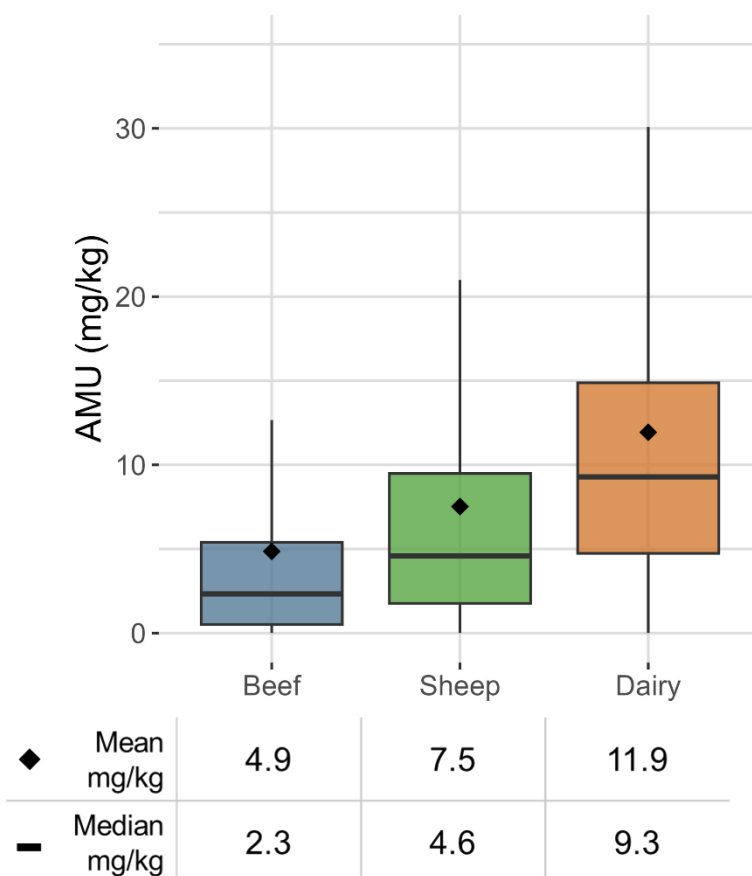
Figure 1: Farm AMU (mg/kg) by enterprise type, 2023
Distribution of total annual AMU for all 2701 beef, 2777 sheep and 582 dairy enterprises in 2023. 5th to 95th percentile are shown. Note: Topical antimicrobials are included in sheep mg/kg only. The methods used to create this graph are detailed in the supplementary information.

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* mg/kg for beef and dairy enterprises was calculated using methodology defined by CHAWG (CHAWG, 2020)
[†] mg/kg for sheep enterprises was calculated using methodology defined by SHAWG (SHAWG, 2019)

AMU by EMA category

Consistent with previous years, use of EMA Category B (Restrict) AMs, by mass of AM ingredient, was very low on all enterprise types. Category C (Caution) AMs made up 49% of all AMs used by mass in dairy, 38% in beef and 17% in sheep enterprises.

In 2020, the EMA updated its classification of AMs to include four categories, from A to D: Avoid, Restrict, Caution and Prudence (Figure 2). AMs were ranked according to the risk that their use in animals poses to public health through the possible development of AMR and the need to use them in veterinary medicine.

Avoid Category A	**Restrict** Category B	**Caution** Category C	**Prudence** Category D
Includes antibiotics that are not currently authorised in veterinary medicine in the European Union (EU).	Refers to quinolones, 3rd- and 4th-generation cephalosporins and polymyxins. These antibiotics are critically important in human medicine.	Antibiotics for which alternatives in human medicine generally exist in the EU, but only few alternatives are available in certain veterinary indications.	Includes antibiotics that should be used as first line treatments, whenever possible. These antibiotics can be used in animals in a prudent manner.

Figure 2: Definitions of EMA categories

Four categories of AMs, from A to D: Avoid, Restrict, Caution and Prudence (EMA, 2020).

Analysis of AMU in 6060 Welsh enterprises highlighted a preference towards Category C (Caution) and D (Prudence) AM products, with little usage of Category B (Restrict) AMs which are critically important in human medicine (Figure 3). Beef enterprises were the highest users of Category B AMs by mass used (0.6%), compared to 0.2% in dairy and <0.1% in sheep. No enterprises reported using Category A (Avoid) AMs. The majority of AM products used in beef and sheep were from Category D, representing 61% and 83% of AM mass used, respectively. In dairy enterprises, 51% of AM products were from Category C, compared to 49% of products from Category D.
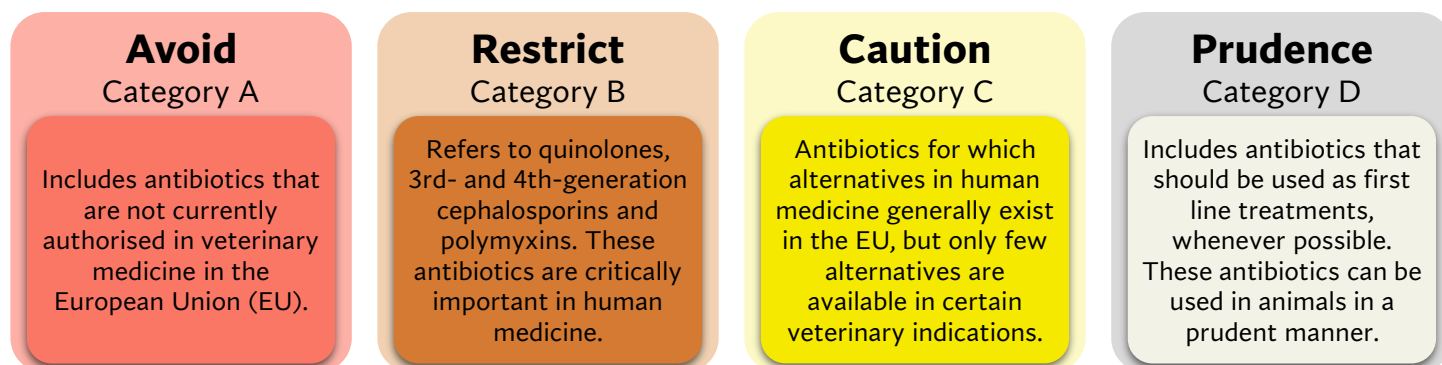

Figure 3: Proportion of AM ingredient used by enterprise type and EMA category, 2023

Proportion by mass of AM ingredient used for all 2701 beef, 2777 sheep and 582 dairy enterprises in 2023, split by AM category. Products with multiple different AM ingredients were placed into categories based on the AM ingredient in the formulation of highest EMA importance (EMA, 2020). See supplementary information for methodology.

AMU by class

By mass of AM, the most used AM classes were tetracyclines, aminoglycosides, aminopenicillins and penicillins. Sheep enterprises used a narrower range of classes compared to beef and cattle enterprises who used a greater range of AM classes.

The percentage of each AM class used by mass was analysed for 2701 beef, 2777 sheep and 582 dairy enterprises in 2023.

Breadth of classes used varied between enterprise types; sheep enterprises used fewer classes, with most use attributing to a select few classes, compared to beef and dairy enterprises where use was spread across a greater range of AMs.

In beef, tetracyclines, penicillins and aminoglycosides made up the majority of use by mass (67%) ([Figure 4]).

In sheep, 52% of the total use by mass was of tetracyclines, whereas aminoglycosides (excl. spectinomycin) and aminopenicillins taken together made up 33%. There was no use of 3rd- or 4th- generation cephalosporins recorded. Spectinomycin use was also very low, at 1% of total use by mass.

In dairy, non-Category B beta-lactams (incl. penicillins and cephalosporins; 33%) and aminoglycosides (excluding spectinomycin; 25%) made up the bulk of AM class use by mass. Tetracyclines and macrolides were also commonly used at 17% and 15% of total use by mass, respectively.

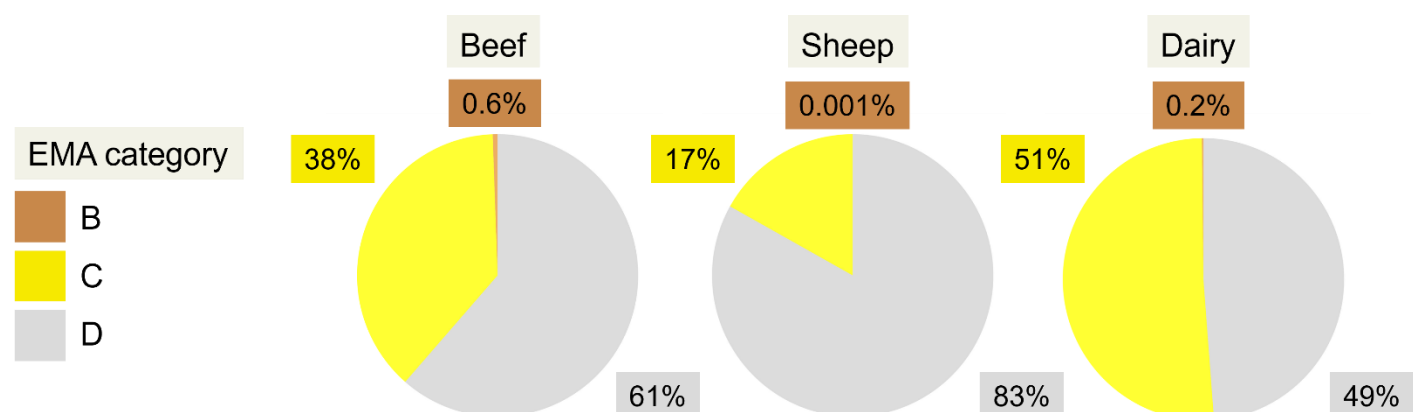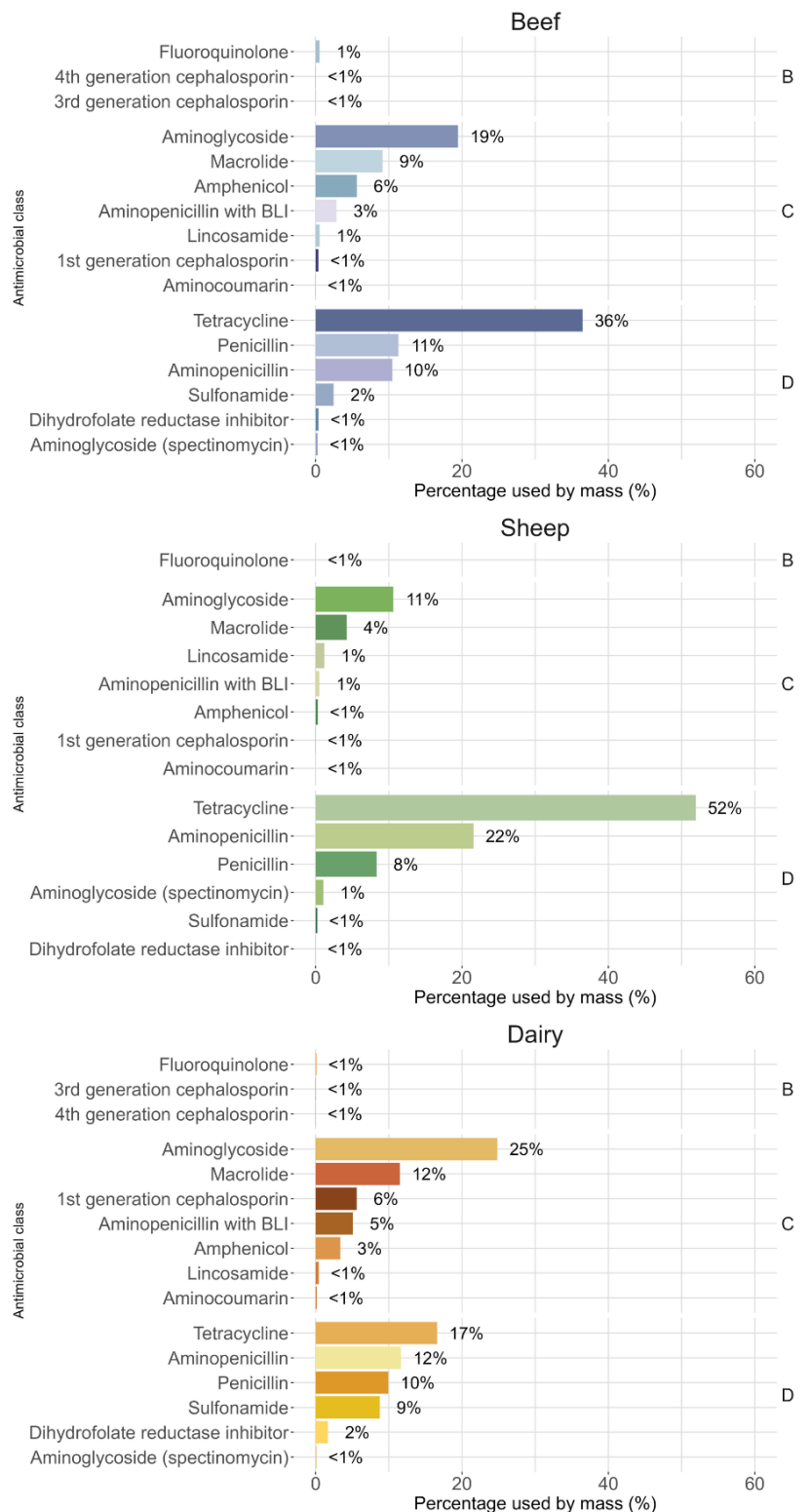**Figure 4: Proportion of AM classes used by enterprise type and EMA category, 2023**

Proportion by mass of AM used for all 2701 beef, 2777 sheep and 582 dairy enterprises in 2023, split by AM class and AM category. See the [supplementary information] for details on the method used. BLI = Beta-lactamase inhibitor.

AMU by administration route

Injectables were the most commonly used administration route by mass of AM used across all three enterprise types. After injectables, the most-used administration route by mass was oral AMs on beef and dairy enterprises, and sprays on sheep enterprises.

The total mass of AMU by product administration route was analysed for 2701 beef, 2777 sheep and 582 dairy enterprises in 2023.

For all three enterprise types, the majority of AMs used by mass were injectable products (Figure 5). In sheep, injectables represented 89% of total AM mass used, compared to 77% in beef and 66% in dairy. This will likely always be the case considering the high mass of active ingredient found in injectable formulations. High levels of injectable usage are also likely to be a significant driver of overall AMU on farm.
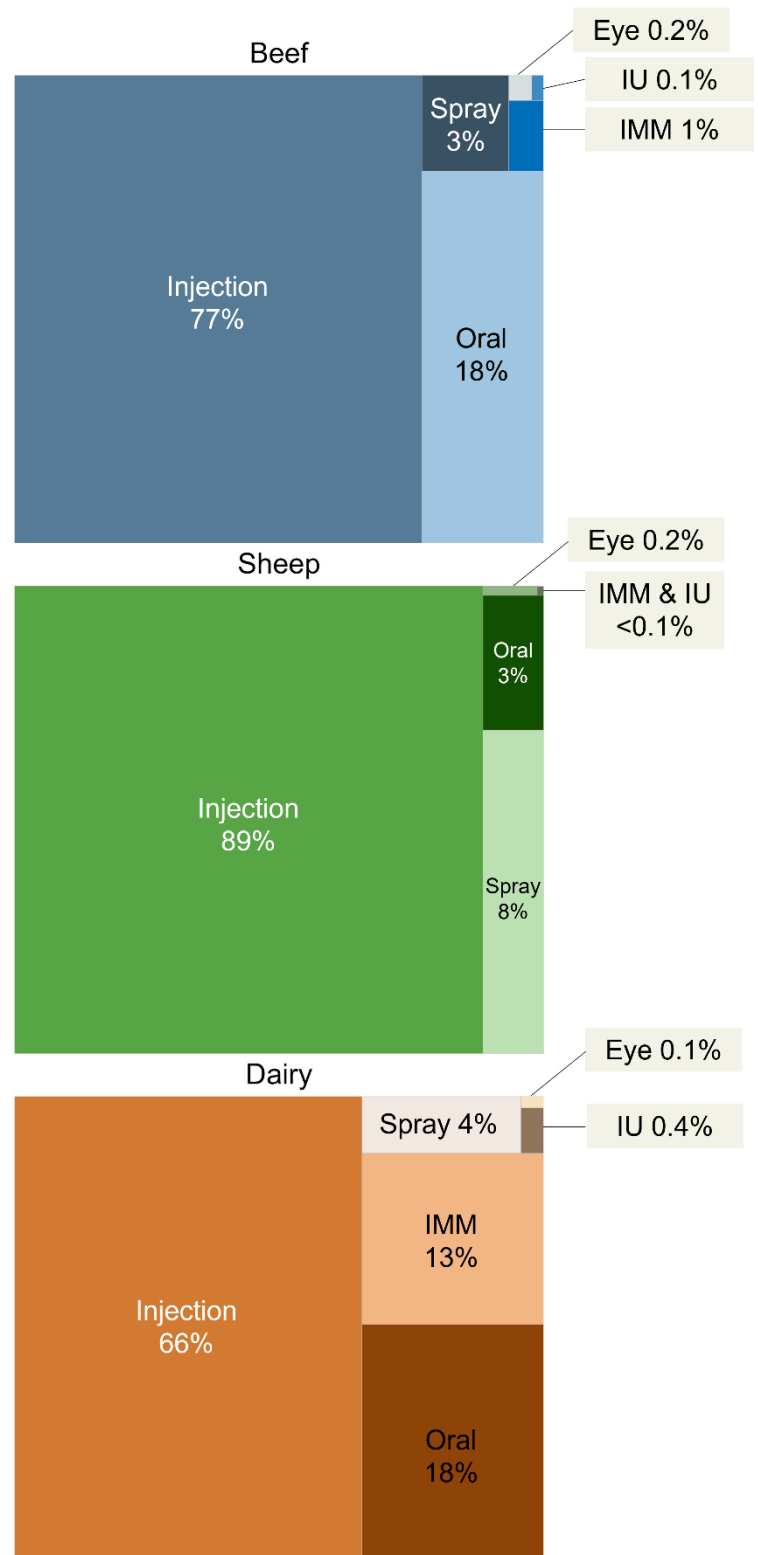
Use of AM sprays was highest in sheep, accounting for 8% of total AM mass used, compared to 4% in dairy and 3% in beef.

Intramammary (IMM) products, first-line AM treatments for mastitis/udder infections, represented 13% of total AM mass used in dairy enterprises in 2023. As expected, IMM products accounted for a smaller proportion of use on beef (1%) and sheep (<0.1%) enterprises.

Oral formulations (e.g. powders, tablets and solutions) represented 18% of AM mass used on dairy and beef enterprises, which was higher than on sheep enterprises (3%).

Figure 5: Proportion of AM products used by enterprise type and administration route, 2023

Proportion of AM by mass used for all 2701 beef, 2777 sheep and 582 dairy enterprises in 2023, split by administration route, as listed in the Veterinary Medicines Directorate's Summary of Product Characteristics for each AM product. See supplementary information for methodology. IU = intrauterine; IMM= intramammary.

Beef

Eye 0.2%
IU 0.1%
IMM 1%
Spray 3%
Injection 77%
Oral 18%

Sheep

Eye 0.2%
IMM & IU <0.1%
Oral 3%
Injection 89%
Spray 8%

Dairy

Eye 0.1%
IU 0.4%
Spray 4%
IMM 13%
Injection 66%
Oral 18%

Intramammary use in dairy

On average, dairy herds in 2023 used more doses of AM products for dry cows than for lactating cows. On average, around 24% of cows were treated with dry cow intramammaries, whilst 18% were treated with lactating cow intramammaries.

The number of doses of intramammary (IMM) AM products used on the 582 dairy enterprises was analysed. A dose was defined as a course of treatment, which for a lactating cow therapy is defined as 3 IMM tubes and a dry cow therapy is 4 IMM tubes (CHAWG, 2020).

Of the 582 dairy enterprises, not all enterprises had data pertaining to the use of dry or lactating cow therapy; 78% recorded at least one AM dry cow therapy sale and 86% recorded at least one AM lactating cow therapy sale.

On average (median), each cow received 0.18 doses of IMM AM lactating cow therapy and 0.24 doses of AM dry cow therapy (Figure 6). This means that, assuming every cow treated received one full dose, on an average (median) enterprise, 18% of cows would have been treated with a course of IMM lactating cow therapy and 24% of cows would have received a course of IMM dry cow therapy. In reality, this percentage could be lower for lactating cow therapies, as the same cow might have been treated multiple times throughout 2023.

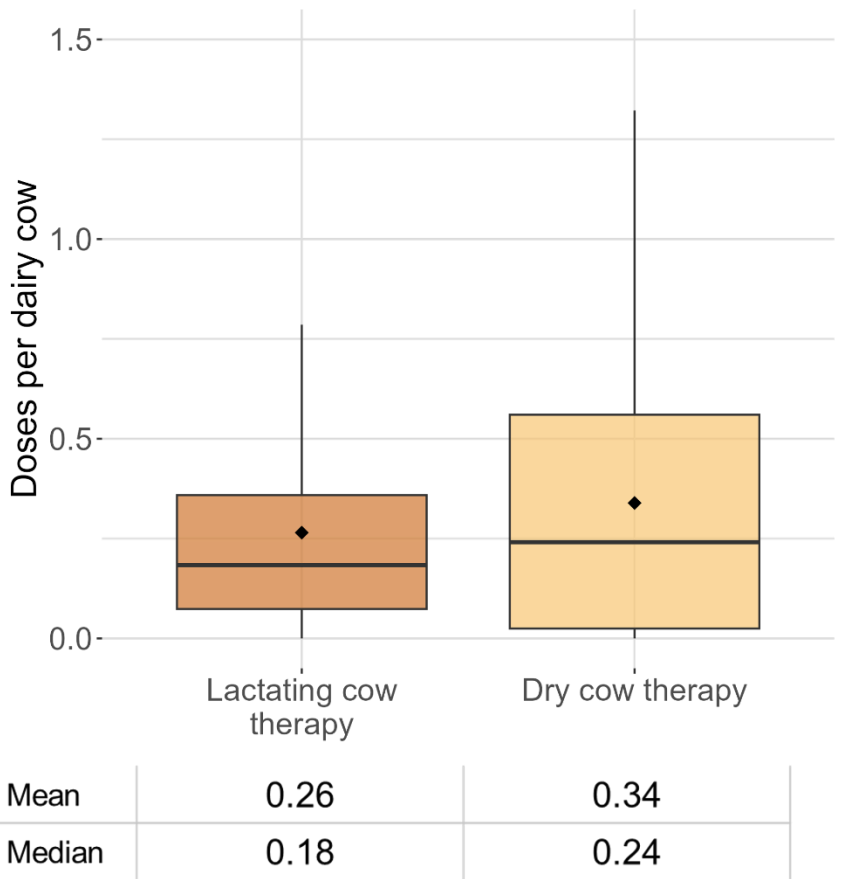|	Lactating cow therapy	Dry cow therapy
◆ Mean	0.26	0.34
▬ Median	0.18	0.24

Figure 6: Doses of intramammary treatments used, 2023

Distribution of doses of lactating cow therapy and dry cow therapy AM intramammary treatments for all 582 dairy enterprises in 2023. 1 lactating cow dose = 3 tubes. 1 dry cow dose = 4 tubes. See supplementary information for methodology.

AM sales through the year by enterprise type

Monthly variation was observed in AM sales across beef, sheep and dairy enterprises. Most month-on-month variation was seen in sheep, with peak AM sales occurring in the Spring months. Dairy enterprises saw sales peaks in Winter and Spring. Far less variation was observed for beef.

Monthly mean AM sales (mg/kg) were analysed for 2701 beef, 2777 sheep and 582 dairy enterprises in 2023. Whilst this analysis gives an indication of how AMU mg/kg changes across the calendar year, it is important to note that the date of AM sale may not accurately represent the date of AM use. Therefore, this analysis should be interpreted as AM sale rather than use.

The largest month-to-month variation in AM sales was seen in sheep, where more AMs were purchased in the Spring season and again peaking in early Autumn (Figure 7).

For dairy enterprises, AM sales peaked in the Winter and Spring months, but dropped in the Summer.

Comparatively, beef enterprises saw less variation in AM sales throughout the year, although followed a similar pattern to sheep and dairy.

As this analysis uses the mass-based metric, mg/kg, this seasonal variation is mostly driven by the purchase of injectables, as, in all enterprise types, these make up the majority of use by mass.
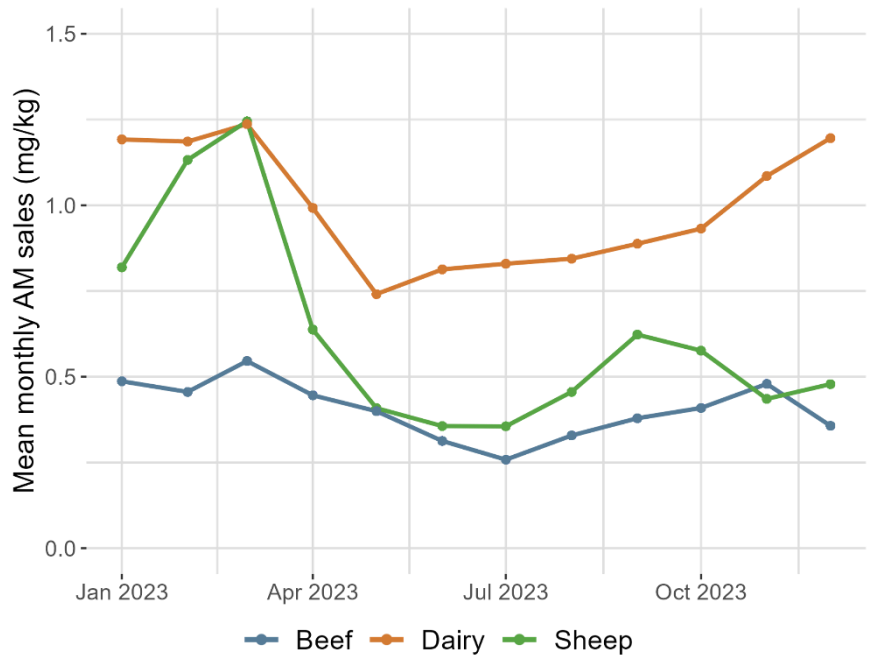

Figure 7: Mean monthly AM sales (mg/kg) by enterprise type, 2023

Mean monthly AM sales (AMU mg/kg) for all 2701 beef, 2777 sheep and 582 dairy enterprises in 2023. Note: Topicals are included in sheep mg/kg only. The methods used to create this graph are covered in the supplementary information.

AM sales through the year by administration route

Monthly variation was seen in sales of AMs by administration route, which varied month-on-month between enterprise types. Seasonal peaks were observed in sales of intrauterine and eye AMs across all enterprises, whilst other AMs, like injectables, were relatively constant over time.

Percentage change in AM sale by mass for each month – comparing monthly percentage of total AM mass to the expected amount (i.e. if AM purchasing was equal across all 12 months) – was analysed for 2701 beef, 2777 sheep and 582 dairy enterprises in 2023.

Monthly percentage change in AM sale by mass was then analysed by administration route for each enterprise type (Figure 8).

In beef, most month-on-month variation in AM sales was observed for intrauterine and oral AMs. Peaks in eye and spray AMs were also observed in early Summer and Autumn, respectively.

In sheep, AM sales were relatively constant over the year, with the exception of Spring where sales of intramammary, eye, oral and injectable AMs peaked. In comparison to beef and dairy, most variation in sales of injectables were seen in sheep. Spring also saw a large increase in intrauterine AM products, but sales of these products ceased after April.

Comparatively, AM sales in dairy herds were much more constant throughout 2023 with few seasonal trends observed. Peaks in AM sales were observed in Summer months, with sprays also peaking in Autumn. Sales of intramammary AMs appeared to also increase in the Winter.
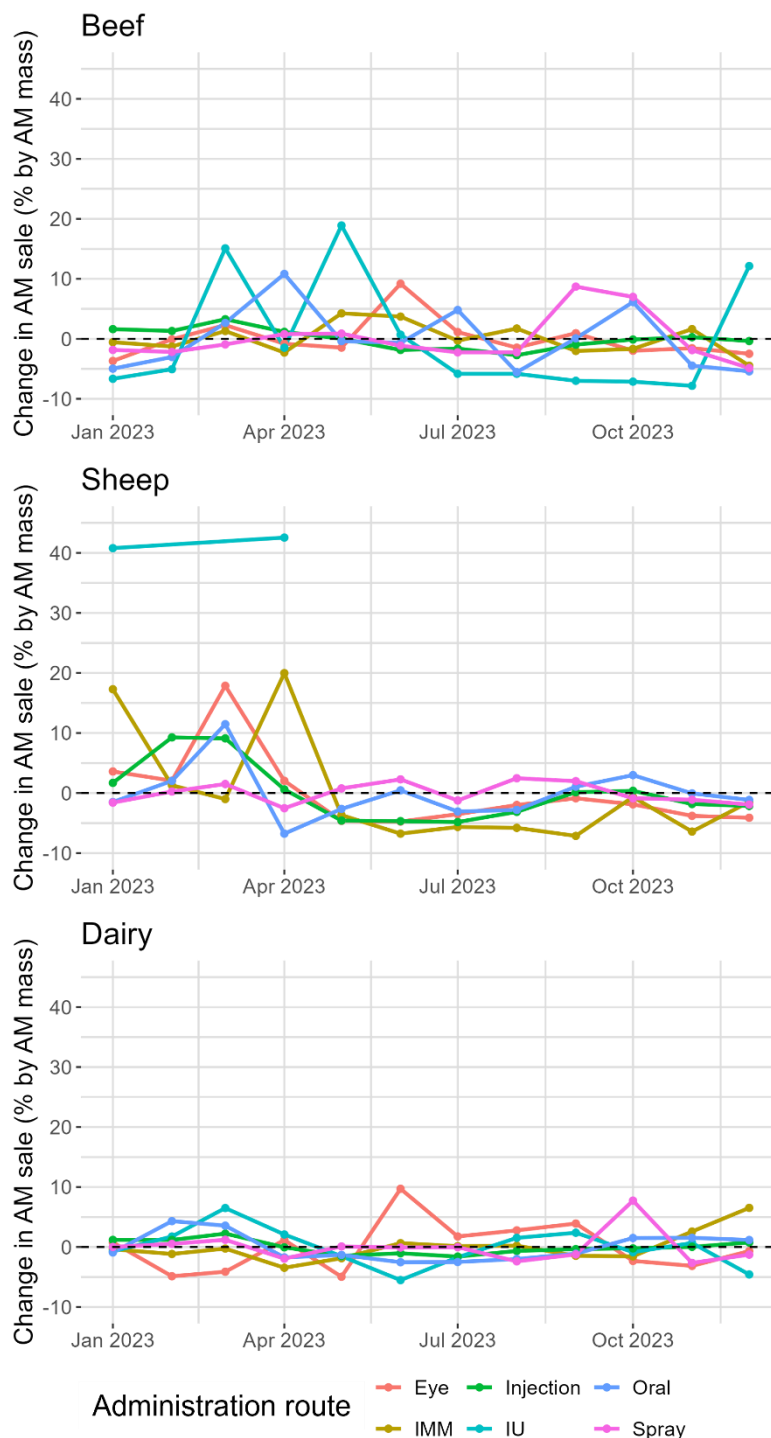

Figure 8: Monthly percentage change in AM sale by mass (mg) by enterprise type and administration route, 2023
Percentage change in AM sale by mass (mg) for all 2701 beef, 2777 sheep and 582 dairy enterprises in 2023, split by administration route. See supplementary information for methodology.

Calculating AMU

Throughout this report, the metric milligrams per kilogram (mg/kg) is used to describe AMU.

Milligrams The total milligrams of active AM ingredient in the product. This is calculated using information from each product's Veterinary Medicine Directorate's (VMD) Summary of Product Characteristics[1] (SPC) Sales records for AM products sold to each farm are reviewed by the veterinary surgeon, who is able to assign products to a herd/flock (for mixed- or multi-enterprise farms) and detail if any product was disposed of (e.g. when a single dose from a multi-dose bottle was used). If product was disposed of, the corresponding milligrams of AM ingredient was then removed from the totals in this analysis. In some cases, exclusions or conversions were made:

- Clavulanic acid was removed from all analyses based on the AMU reporting recommendations (CHAWG, 2020; SHAWG, 2019; ESVAC, 2021).
- Where products are listed as pro-drugs, ESVAC conversion factors have been applied to calculate the milligrams of active moiety (ESVAC, 2021).
- Where products are listed using international units (IU), the ESVAC recommended conversion factor has been applied (ESVAC, 2021).
- Topical AM products (sprays and eye ointments) are excluded when quoting mean or median total use in a population (**Figure 1**) for dairy and beef herds, but are included for sheep flocks. This methodology follows the AMU reporting recommendations (CHAWG, 2020; SHAWG, 2019).

Kilograms The total kilograms of animals at risk of treatment in the herd/flock. These are calculated by WLBP from animal numbers either provided automatically or manually by farmers and veterinary surgeons when using the AMU Calculator. Tables S.1 - 3 below show the animal weights and reference the methodology used.

- In the case of beef:
  - 45% of herds were linked to the British Cattle Movement Service Cattle Tracing System and animal numbers were pulled automatically as opposed to using veterinary surgeon- or farmer-reported animal counts. These herds have a different method of calculating weights which aligns with ESVAC (ESVAC, 2021). Median AMU of these farms was 6.2 mg/kg.
  - 55% of beef herds relied on the veterinary surgeon/farmer entering animal counts and used the CHAWG simplified mg/kg$^{beef\ farm}$ metric (CHAWG, 2020). Median AMU of these farms was 5.4 mg/kg.

Limitations:

- For total kilograms of animal at risk of treatment, the 2 different methodologies explained above were used for beef herds. If one of these methodologies over- or under-estimates animal weight, the comparisons between these farms could be invalid.
- The mg/kg metric does not attempt to assign medicines to youngstock or adult cattle and therefore assumes that all animals on the farm were at risk of treatment. This may not accurately reflect how AMs are used (for example, intramammary tubes would not be used in non-lactating animals).

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[1] VMD SPCs were accessed online via the VMD Product Information Database (www.vmd.defra.gov.uk/ProductInformationDatabase)

Table S.1: Beef weights

Count type	Herd type	Age group (years)	Sold for slaughter?	Sex	Time since arrival on farm (years)	WLBP AMU Calculator assigned weight (kg)	Method reference
Beef numbers manually entered by the veterinary surgeon	Beef fattening	<1	N	Mixed	<1	104	CHAWG simplified mg/kg[beef farm] metric[2]
		1 to 1.5	N	Mixed	<1	250	
		>1.5	N	Mixed	<1	144	
		1 to 1.5	N	Mixed	1 to 1.5	428	
		>1.5	N	Mixed	1 to 1.5	204	
		>1.5	N	Mixed	>1.5	146	
		<1	Y	Mixed	<1	28	
		1 to 1.5	Y	Mixed	<1	325	
		>1.5	Y	Mixed	<1	177	
		1 to 1.5	Y	Mixed	1 to 1.5	627	
		>1.5	Y	Mixed	1 to 1.5	403	
		>1.5	Y	Mixed	>1.5	199	
	Calf rearing	<1	N	Mixed	N/A	41	
		1 to 1.5	N	Mixed	N/A	323	
		>1.5	N	Mixed	N/A	482	
		<1	Y	Mixed	N/A	91	
		1 to 1.5	Y	Mixed	N/A	413	
		>1.5	Y	Mixed	N/A	680	
	Suckler	>1	N	Female	N/A	762	
		<1	N	Mixed	N/A	0	
		1 to 1.5	N	Mixed	N/A	266	
		>1.5	N	Mixed	N/A	453	
		<1	Y	Mixed	N/A	174	
		1 to 1.5	Y	Mixed	N/A	343	
		>1.5	Y	Mixed	N/A	655	
		<1	N	Female	N/A	367	
Beef numbers automatically sourced [1]	All	<1	N/A	Mixed	N/A	140	ESVAC PCU[3]
		1 - 2	N/A	Female	N/A	200	
		>1	N/A	Male	N/A	425	
		>2	N/A	Female	N/A	425	

1] Sourced from the British Cattle Movement Service.
2] CHAWG, 2020
3] ESVAC, 2021

Table S.2: Sheep weights

Count type	Description	WLBP AMU calculator assigned weight (kg)	Method reference
Flock numbers manually entered by the veterinary surgeon	Adult ewes put to the ram	75	SHAWG mg/kg[sheep farm] metric[1]
	Lambs sold as stores	20	
	Lambs sold for slaughter	20	
	Lambs sold for breeding or kept for breeding	20	

1] SHAWG, 2019

Table S.3: Dairy weights

Count type	Description	WLBP AMU calculator assigned weight (kg)	Method reference
Dairy numbers manually entered by the veterinary surgeon	Number of milking cows	425	ESVAC PCU2 – analogous to CHAWG mg/kg[3]
Dairy numbers automatically sourced [1]	Number of milking cows	425	

1] Sourced from the British Cattle Movement Service
2] ESVAC, 2021
3] CHAWG, 2020

Reporting average values

This report calculates the AMU in mg/kg for each farm in the WLBP AMU Calculator dataset and then describes these using averages to reflect the AMU of a typical farm in Wales. Averages are a way of summarising data by describing centrality. Two types of average, which have slightly different meanings, are used within this report:

Median: The median describes the middle value when data are ordered from least to greatest. It is equal to the 50th percentile of the dataset. 50% of the data lie below the median, and 50% above.

Mean: The arithmetic mean is calculated by totalling all values and dividing by the number of datapoints:

$$\text{Mean AMU} \ = \frac{Sum\ of\ all\ farms'\ AMU}{Number\ of\ farms}$$

The median is a more useful average to report when data are non-normally distributed. Enterprise AMU is often non-normally distributed due to the presence of outliers, especially enterprises with very high AMU. Where there are outliers with high AMU, the mean is expected to be larger than the median. An enterprise with lower than median AMU can consider themselves in the lower 50% of AMU users. The authors therefore recommend using median to report average AMU but provide mean AMU alongside this for comparison with other calculations.

Data displayed as boxplots (Figure 1 and 6)

The parts of the boxplot used in the report are explained in the diagram (Figure S.1). Farms whose use was less than the 5th or greater than 95th percentile are not shown on the plot, but their data were used to calculate the mean and median. If the mean is greater than the median, it indicates a 'long tail': a few enterprises which have very high use.
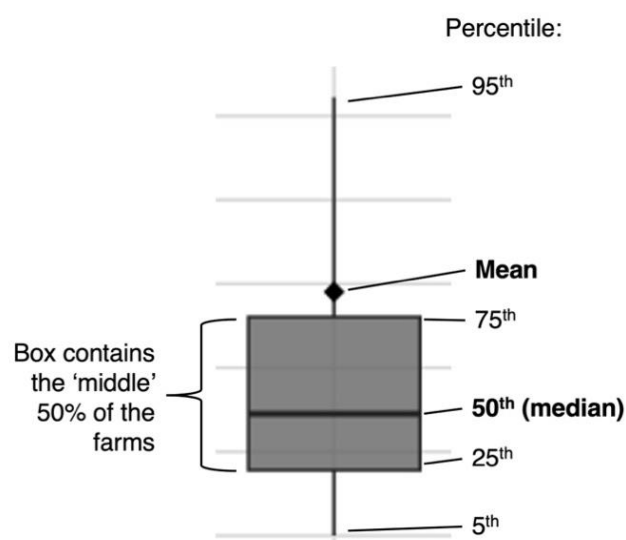

Figure S.1: Interpreting boxplots

Figure 3: Proportion of AM ingredient used by enterprise type and EMA category, 2023

Method: Products were grouped into EMA categories ([EMA, 2020](#)) based on the class of AM ingredients they contained. Products with multiple different AM ingredients were categorised according to the AM ingredient in the formulation with the highest EMA category.

Limitations: As this analysis is based on mass of AM ingredient, low-potency AMs such as tetracyclines contribute more to the total mass than high-potency AMs such as 3rd generation cephalosporins. Future reports aim to also report dose-based AMU metrics, such as DDDvet ([ESVAC, 2016](#)).

Figure 4: Proportion of AM classes used by enterprise type and EMA category, 2023

Method: AM ingredient was taken from the VMD SPC for each AM product. Proportion by mass (mg) of each class used was calculated.

Limitations: Same as limitations for Figure 3.

Figure 5: Proportion of AM product used by enterprise type and administration route, 2023

Method: Administration route was taken from the VMD SPC for each product, and the proportion by mass (mg) of each AM product used was calculated.

Limitations: The administration route listed on the SPC may not reflect the administration route used by the veterinary surgeon and farmer. For example, oral powders are sometimes used off-label in footbaths. Therefore, this analysis may not be indicative of the administration route used for each product.

Figure 6: Doses of intramammary treatments used, 2023

Method: Doses for dry cow and lactating cow AM-containing intramammary (IMM) products were calculated using methodology defined by CHAWG ([CHAWG, 2020](#)). For dry cow therapy: 1 dose = 4 tubes; for lactating cow therapy: 1 dose = 3 tubes (over the course of treatment, an average of 3 tubes are applied to one quarter). The following equation was used to calculate doses per cow for each dairy enterprise:

$$\text{Doses per cow} = \frac{Number\ of\ IMM\ doses}{Number\ of\ adult\ cows}$$

Limitations: These calculations assume the number of tubes used per course to be 4 (for dry cow therapy) and 3 (for lactating cow therapy), whereas a farmer or veterinary surgeon, in reality, may have used a different number of tubes.

Figure 7: Mean monthly AM sales (mg/kg) by enterprise type, 2023

Method: The date of AM transaction was used to group 2023 AM sales into months. The mean monthly AMU (mg/kg; see "Calculating AMU" for methodology) was calculated for each month for each enterprise type (beef, sheep, dairy).

Limitations: The date of AM transaction may not accurately represent the date of AM use, as farmers may store some AMs on farm for future use, so this analysis should be considered indicative of AM sales <u>only</u>.

Figure 8: Monthly percentage change in AM sale by mass (mg) by enterprise type and administration route, 2023

Method: The percentage of the 2023 total AM mass purchased in each month (i.e. relative increase or decrease in mass [mg] of AMs) by administration route and enterprise type was calculated using the following equation:

$$\text{Relative increase or decrease in AM sales by mass (mg)} = \frac{Total\ AM\ purchased\ that\ month\ (\frac{mg}{kg})}{Total\ AM\ purchased\ over\ year\ (\frac{mg}{kg})} x100$$

This was then compared to the expected amount (i.e. if AM was purchased equally across the whole year) and the difference was reported as the 'change in sale (% by AM mass)'. Values >0% indicate an increase in purchasing in those months, whereas values <0% indicate a decrease in purchasing.

Limitations: Same as limitations for Figure 7.

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