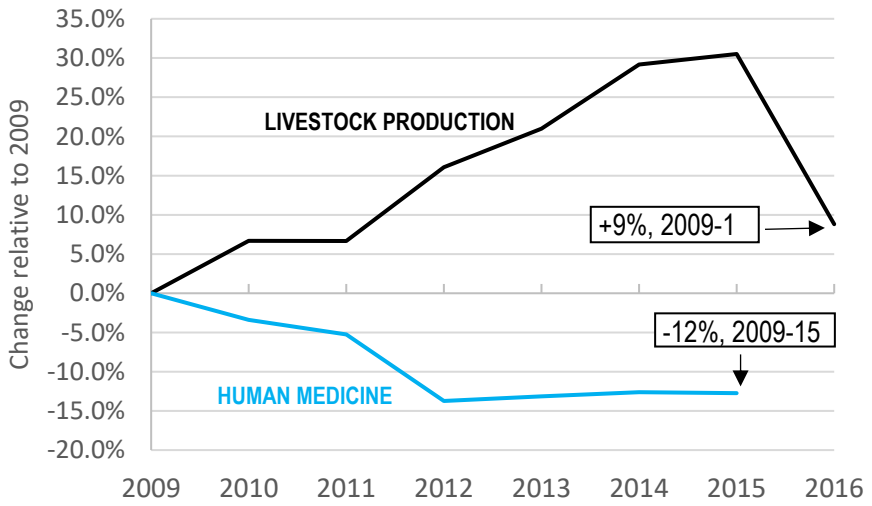
FIGURE 1. RELATIVE CHANGE IN INTENSITY OF ANTIBIOTIC CONSUMPTION FOR HUMANS AND ANIMALS OVER TIME

With figure 1, our aim is to compare recent changes in how medically important antibiotics have been consumed in human medicine and in the livestock sector from 2009 to 2015/2016, adjusting in each case by the size of the potential human or animal population to which those drugs were administered.



We use the same, weight-adjusted metric for expressing antibiotic consumption intensity in livestock production as does the European Medicines Agency (EMA), Public Health Canada and the Veterinary Medicines Directorate in the United Kingdom. The measure divides the total sales of antibiotics, in milligrams of active ingredient, by the estimated weight of all the animals, in kilograms, at the time they most likely would be given antibiotics. EMA describes this estimate of livestock weight, adjusted to the time of treatment, as a "Population Correction Unit" or "PCU" and refers to the overall metric as milligrams of antibiotic per PCU. For many years, the EMA's European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) has been calculating mg of antibiotics/kg of livestock (or mg/PCU) for up to 30 countries.

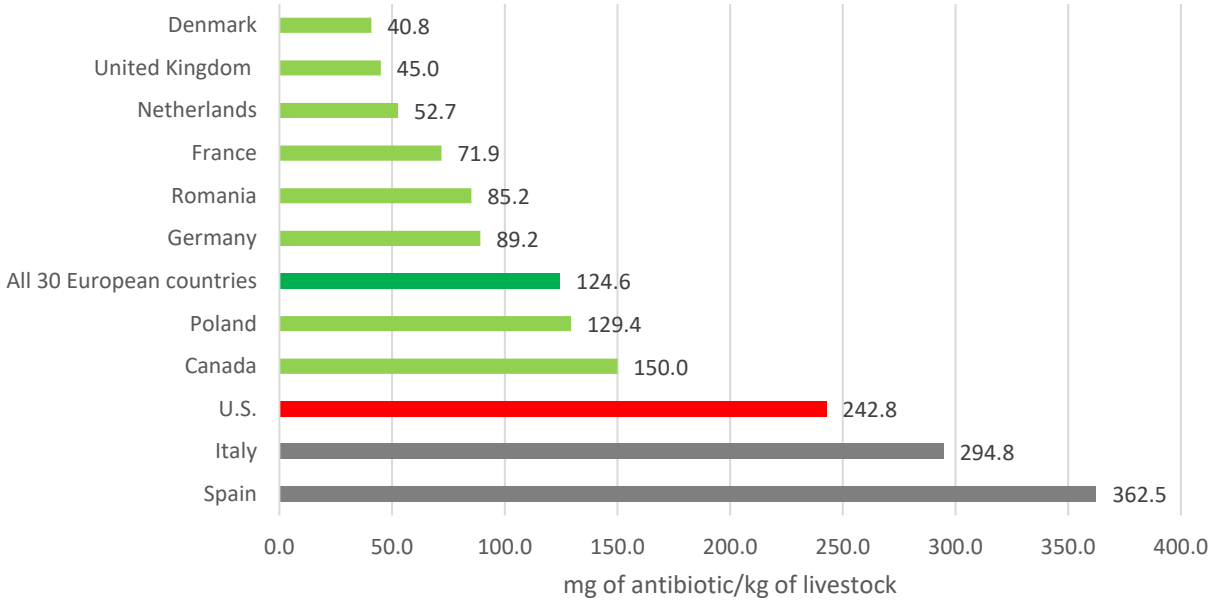
The fact sheet notes the 2017 recommendation of an independent expert commission that this same method be used to track U.S. progress in reducing livestock antibiotic use, as well. We consider this to be the only currently available method for making antibiotic consumption comparisons between the U.S. livestock sectors and their counterparts elsewhere, given the still-limited data that U.S. authorities currently make available on the antibiotic use in livestock production.

Sources

1. U.S. Food and Drug Administration, Center for Veterinary Medicine. "2016 Summary Report on Antimicrobials Sold or Distributed for Use in Food-Producing Animals." December 2017. https://www.fda.gov/AnimalVeterinary/NewsEvents/CVMUpdates/ucm588086.htm.
2. We calculated the weight of the U.S. livestock population at risk for receiving antibiotics, also known as the PCUs or Population Correction Units, using USDA animal census data, combined with the published methodology used by the ESVAC project of the European Medicines Agency, available at in Appendix 2 of the 2011 report, 'Trends in the sales of veterinary antimicrobial agents in nine European countries: 2005-2009 (EMA/238630/2011). This method also is described in somewhat greater detail in the next section.
3. Data on 2015 sales of antibiotics for human medicine in the United States were obtained from Eili Klein of the Center for Disease Dynamics, Economics & Policy (CCDEP). Klein also provided data for years prior to 2015 in Kar, A., and Klein, E. "Animal Antibiotic Sales Finally Drop, but Much Work Remains." Natural Resources Defense Council. December 2017. https://www.nrdc.org /experts/avinash-kar/animal-antibiotic-sales-finally-drop-much-work-remains. U.S. sales figures for antibiotics in human medicine are not yet available for 2016.
4. United States Census Bureau. "2000-2009: Intercensal Resident Population Estimates", and "2010-2018: Monthly Population Estimates for the United States". Both available at www.census.gov.

FIGURE 2. INTENSITY OF ANTIBIOTIC CONSUMPTION IN 2016 AMONG U.S., CANADIAN AND TOP EU LIVESTOCK PRODUCERS

Figure 2 compares the amount of antibiotics sold for livestock production in 2016, by country, adjusted by the estimated weight in kilograms of all animals in that country at the time they likely are given antibiotics. The most recent (October 2018) report of the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) Project of the European Medicines Agency supplies this ratio of mg of antibiotics/kg of livestock (or mg/PCU) for 30 countries.[1](That report, however, does not offer species-specific mg/PCU estimates). In addition to the nine countries highlighted in Figure 2, the 30 European countries also include Norway, Ireland, Belgium, Greece, Portugal, Austria, Hungary, Switzerland, Sweden, Czech Republic, Finland, Bulgaria, Lithuania, Croatia, Slovakia, Latvia, Slovenia, Lithuania, Estonia, Iceland, Cyprus, and Luxembourg.



Antibiotic sales figures for these countries antibiotics sold for use in livestock production, as well as in companion animals (typically in pill form); across the European Union, however, companion animals account for less than 1 percent of the total. After an EU-wide ban went into effect in 2006 on use of non-medically important antibiotics in livestock feed for growth promotion, virtually all antibiotics sold are those considered to be medically important. Sales figures for medically important antibiotics for use in livestock production in the United States and Canada also are from 2016, and are reported by the Food and Drug Administration (FDA) and Public Health Canada, respectively.[2,3] Globally, antibiotic sales for use in livestock have long been considered an appropriate proxy for actual antibiotic use on farms, given that the latter data are not collected or reported by many countries including the U.S. and Canada.

Figure 2 is constructed from the data in the table below, which lists antibiotic sales by country, along with the total estimated livestock weight and the mg/kg of livestock calculated (mg/PCU) for each.[4] Essentially, the estimated total weight of each animal category is calculated by multiplying the total number live animals (dairy cows, sows) and slaughtered animals (cattle, pigs, turkeys and broiler chickens) by the average weight at the most likely time antibiotics would be administered. It also

considers the numbers of live pigs, cattle or other animals each year that are imported or exported for fattening or for slaughter.

The ratio of antibiotics sold adjusted by estimated livestock weight at time of antibiotic treatment is expressed as mg of antibiotic active ingredient/kg of livestock. One kg of livestock is equivalent to one PCU. The mg of antibiotics/kg of livestock for individual European countries, and for the 30 European countries collectively, are listed in Table 4 of the ESVAC report. Public Health Canada derived its own mg/kg of livestock figures for 2016, which can be found in the latest CARSS report.

Since no public agency has made the same calculations for the United States, we did so, also using the ESVAC methodology. They are represented in Figure 2 and the table below. Mg of antibiotics/kg of livestock for the U.S. are based upon USDA inventories of live and slaughtered animals, including live dairy cattle and sows, slaughter-weight pigs, cattle, chickens, sheep and goats, as well as imported/exported animals.[5]

Country	Antimicrobial sales (metric tonnes) for food-producing animals	Est. weight of all animals (1,000 metric tonnes)*	mg of antibiotics/ kg of livestock
Denmark	98.7	2,420	40.8
United Kingdom	321.7	7,142	45.0
Netherlands	181.7	3,446	52.7
France	513.9	7,143	71.9
Romania	265.4	3,116	85.2
Germany	779.2	8,734	89.2
All 30 European countries	7,787.1	62,521	124.6
Poland	570.2	4,407	129.4
Canada	987.2	6,581	150.0
U.S.	8,361.7	34,444	242.8
Italy	1,213.2	4,116	294.8
Spain	2,724.9	7,518	362.5

[1] See European Medicines Agency, European Surveillance of Veterinary Antimicrobial Consumption, *Sales of veterinary antimicrobial agents in 30 European countries in 2015*. EMA/184855/2017, page 29.

[2] U.S. Food and Drug Administration (FDA), Center for Veterinary Medicine. 2016 Summary Report on Antimicrobials Sold or Distributed for Use in Food-Producing Animals. December 2017. Table 14, p. 65. Note that sales of all medically important antibiotics for 2016 (active ingredient) are 8,361,700 kg, or 8361.7 tonnes. Note that this figure includes 216,771 kg of active ingredient for medically important antibiotics that the FDA lumps into its NIR (not independently reported) category.

[3] Canadian Antimicrobial Resistance Surveillance System, 2017 Report. March 2018. 126 pages. Accessed at https://www.canada.ca/content/dam/ phac-aspc/documents/services/publications/drugs-health-products/canadian-antimicrobial-resistance-surveillance-system-2017-report-executive-summary/CARSS-Report-2017-En.pdf.

[4] The definition of PCUs and how they are calculated can be found in Appendix 2 of European Medicines Agency, ESVAC (2011). 'Trends in the sales of veterinary antimicrobial agents in nine European countries: 2005-2009 (EMA/238630/2011).

[5] See http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1096 for live and slaughtered animal figures for sows and all other species. For slaughter hogs, see https://www.nass.usda.gov/. Figures on imported and exported slaughter cows and dairy cows are from USDA's Economic Research Service (ERS). *Cattle: Annual and cumulative year-to-date U.S trade - All years and countries.* Last updated March 7, 2018; Imported and exported slaughter hogs and fattening hogs are from ERS. *Hogs: Annual and cumulative year-to-date U.S trade - All years and countries*, as updated March 7, 2018; Imported and exported broiler chickens are from ITC Trade Map. *List of exporting markets for a product imported by United States of America*, Product 010594 Live fowls of the species *Gallus domesticus*, weighing > 185. Accessed July 16, 2018 at https://www.trademap.org/.

FIGURE 3. INTENSITY OF ANTIBIOTIC CONSUMPTION, BY U.S. FOOD ANIMAL SECTOR

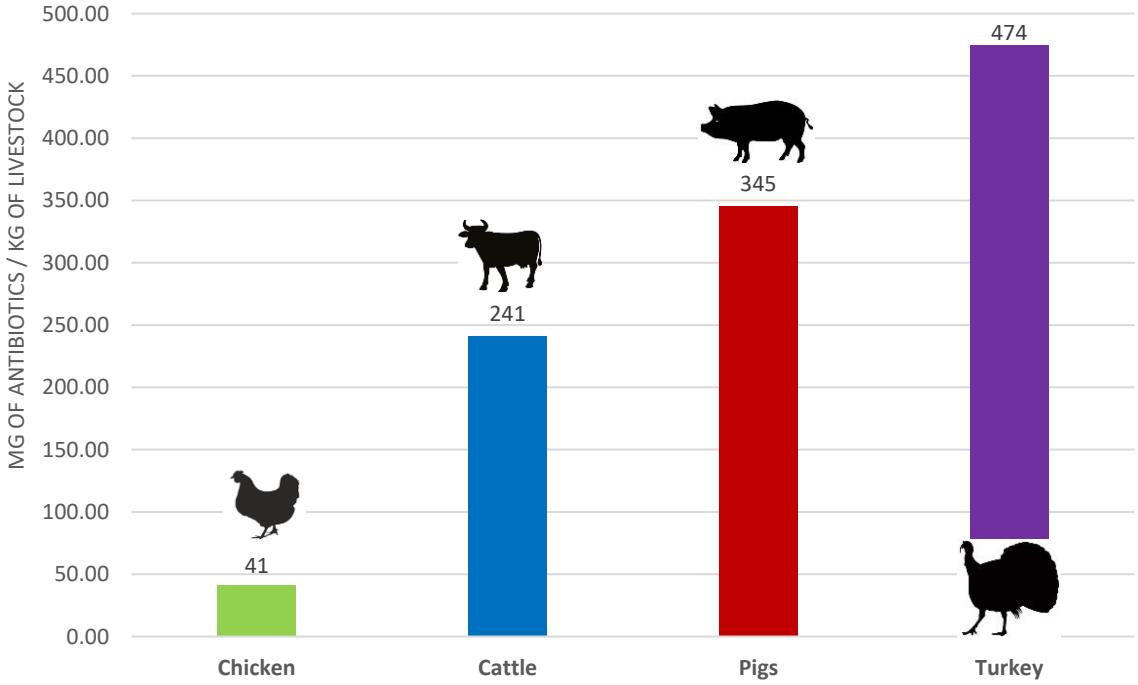


Figure 3 depicts how intensively the four major, conventional U.S. food animal sectors consume medically important antibiotics, in milligrams of antibiotic per kg of livestock.

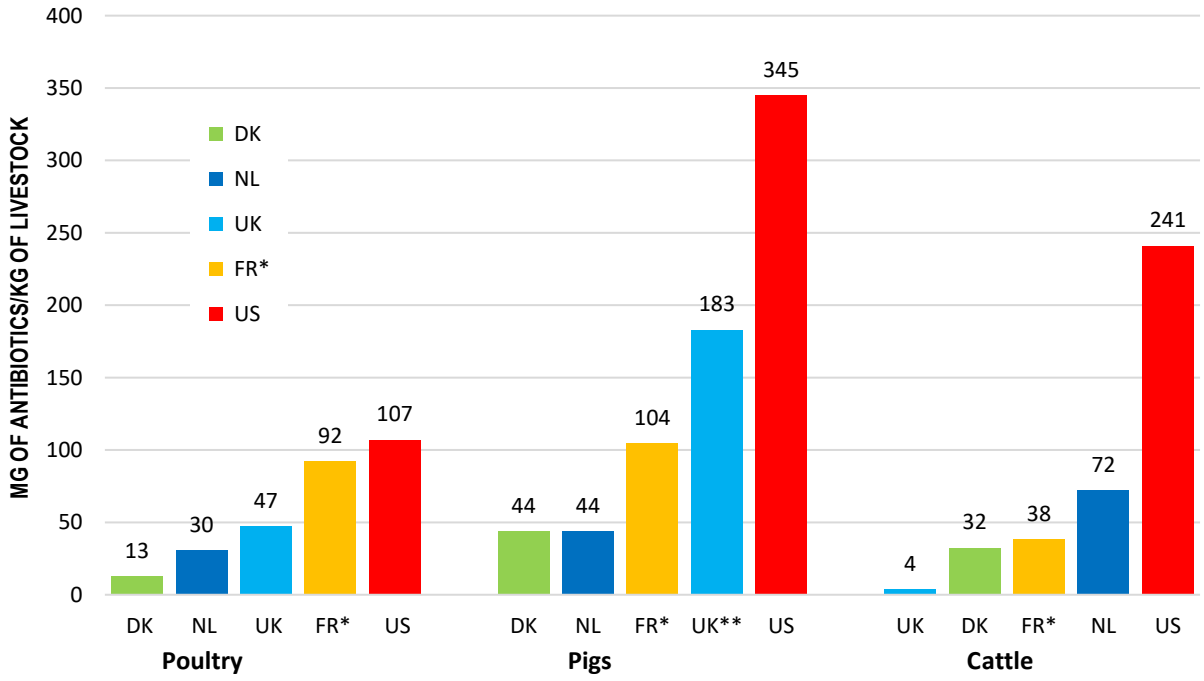
The table below indicates our calculated kilograms of livestock for cattle, pigs and poultry in the United States in 2016. The miscellaneous category refers to sheep, goats, rabbits, horses, etc. Again, our calculations reflect the method developed by the European Medicine Agency, as described in Appendix 2 of its 2011 report.[1] Numbers of slaughtered cattle, pigs, poultry and other miscellaneous food animals for 2016 were obtained from USDA. For the purpose of comparison, we assumed that the average weights of animals in the U.S. are the same as those in the European Union.

	Kilogram of livestock
Cattle	14,786,863,065
Pigs	8,983,622,465
Poultry	10,349,776,036
Chicken	*8,768,618,536*
Turkey	*1,581,157,500*
Miscellaneous	324,051,288
Total	**34,444,312,854**

Also factoring into mg of antibiotics/kg of livestock for the chicken, cattle, swine, and turkey sectors, as represented in Figure 3, are FDA's latest (2016) sales figures for medically important antibiotics sold for use in food animal production. Total sales amounted to about 8,362 metric tonnes of antibiotic active ingredient, of which about 43% were for cattle, 37% for pigs, 9% for turkeys and 6% for chickens.[2] The latter two can be combined into a single figure for poultry overall, although the use of antibiotics is tremendously different in turkey vs. chicken production.

[1] Available at http://www.ema.europa.eu/docs/en_GB/document_library/Report/2011/09/WC500112309.pdf.
[2] U.S. Food and Drug Administration (FDA), Center for Veterinary Medicine. 2016 Summary Report on Antimicrobials Sold or Distributed for Use in Food-Producing Animals. December 2017.

FIGURE 4. INTENSITY OF ANTIBIOTIC CONSUMPTION IN POULTRY, PIG AND CATTLE PRODUCTION IN THE U.S., FRANCE, UNITED KINGDOM, NETHERLANDS AND DENMARK IN 2016



* For France, the estimates of antibiotic consumption intensity used are those found in the 2016 report from the European Surveillance of Veterinary Antimicrobial Consumption project, and not those reported by ANSES in October 2017. See text for more information.
** More recent data indicate that in 2017 the antibiotic consumption in UK pig production decreased by an additional 19 percent, relative to the level used in 2015. See text for more information.

Among the 30 European countries for which the ESVAC project current tracks data on antibiotic consumption and use in livestock production, there are four – France, the United Kingdom, the Netherlands and Denmark – for which species-specific figures on mg of antibiotics/kg of livestock (or mg/PCUs) are available for 2016. Figure 4 compares those to the 2016 figures we have calculated for poultry, pig and cattle production in the U.S.

Consumption intensity in UK pig production represents a 34 percent decrease relative to 2015 levels; the UK Pig Association reports that in 2017, there was a further drop in intensity to 131 mg/kg animal, and the industry has set its own target for further reductions to 99 mg/kg animal by the year 2020.[1,2] Despite already having the lowest antibiotic consumption in pig production among the countries represented in Figure 4, Denmark reports that the amount of antibiotics used in the sector dropped around 8 percent in 2017 compared to 2015 levels.[3,4]

In the case of France, there are two different mg/kg of animal estimates available for 2016. The estimates reflected in Figure 4 are those calculated using French data contained in the most recent ESVAC report. Even more recently, the French Agency on Food, Environmental and Occupational Health and Safety released its annual report on antimicrobial sales for use in livestock production.[5] That report changes the method for calculating the size of the animal population being treated, so that if used the figures for poultry, pigs and cattle in France would be roughly twice as large, 1.5 times as large, and nearly three times larger, respectively, than the

PCUs given in the ESVAC report. For the purpose of Figure 4, we elected to use the latter, instead.

Antibiotic sales (kg)

	Denmark	France	United Kingdom	Netherlands	United States
Poultry	1,560	105,570	NA	12,122	1,110,532
Pigs	78,150	189,400	NA	73,453	3,100,914
Cattle	13,151	124,350	NA	87,198	3,561,943
PCU (1,000 kg)					
Poultry	123,000	1,145,000	1,151,000	398,000	10,349,776
Pigs	1,773,000	1,815,000	789,000	1,685,000	8,983,622
Cattle	398,000	3,240,000	1,792,000	1,174,000	14,786,863

[1] UK-VARSS 2016. UK Veterinary Antibiotic Resistance and Sales Surveillance Report. 2017. Access at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/707974/_1274590-v2-VARSS_2016_for_GOV.pdf

[2] National Pig Association. Pig Industry Antibiotic Stewardship Program. July 2018. Accessed at http://www.npa-uk.org.uk/hres/NPA%20Pig%20Industry%20Stewardship%20Programme%20July%202018.

[3] The Danish Integrated Antimicrobial Resistance Monitoring and Research Program (DANMAP) DANMAP 2016 - Use of antimicrobial agents and occurrence of antimicrobial resistance in bacteria from food animals, food and humans in Denmark. ISSN 1600-2032. Accessed at www.danmap.org.

[4] The Danish Integrated Antimicrobial Resistance Monitoring and Research Program (DANMAP) DANMAP 2017 - Use of antimicrobial agents and occurrence of antimicrobial resistance in bacteria from food animals, food and humans in Denmark. ISSN 1600-2032. Accessed at www.danmap.org.

[5] ANSES (French agency for food, environmental and occupational health and safety). Annual Report: Sales survey of veterinary medicinal products containing antimicrobials. October 2017. Access at https://www.anses.fr/en/system/files/ANMV-Ra-Antibiotiques2016EN.pdf.