Critical review of AMR risks arising as a consequence of using biocides and certain heavy metals in food animal production: References

Aarestrup, F. M., Cavaco, L., & Hasman, H. (2010). Decreased susceptibility to zinc chloride is associated with methicillin resistant Staphylococcus aureus CC398 in Danish swine. Veterinary Microbiology, 142(3-4), 455-457. https://doi.org/10.1016/j.vetmic.2009.10.021

Abd El-Aziz, N. K., Ammar, A. M., El Damaty, H. M., Abd Elkader, R. A., Saad, H. A., El-Kazzaz, W., & Khalifa, E. (2021). Environmental Streptococcus uberis associated with clinical mastitis in dairy cows: virulence traits, antimicrobial and biocide resistance, and epidemiological typing. Animals, 11(7), 1849. https://doi.org/10.3390/ani11071849

Agga, G. E., Scott, H. M., Amachawadi, R. G., Nagaraja, T. G., Vinasco, J., Bai, J., Norby, B., Renter, D. G., Dritz, S. S., Nelssen, J. L., & Tokach, M. D. (2014). Effects of chlortetracycline and copper supplementation on antimicrobial resistance of fecal Escherichia coli from weaned pigs. Preventive Veterinary Medicine, 114(3-4), 231-246. http://dx.doi.org/10.1016/j.prevetmed.2014.02.010

Agga, G. E., Scott, H. M., Vinasco, J., Nagaraja, T. G., Amachawadi, R. G., Bai, J., Norby, B., Renter, D. G., Dritz, S. S., Nelssen, J. L., & Tokach, M. D. (2015). Effects of chlortetracycline and copper supplementation on the prevalence, distribution, and quantity of antimicrobial resistance genes in the fecal metagenome of weaned pigs. Preventive Veterinary Medicine, 119(3-4), 179-189. http://dx.doi.org/10.1016/j.prevetmed.2015.02.008

Ajewole, O. A., Ikhimiukor, O. O., & Adelowo, O. O. (2021). Heavy metals (Cu and Zn) contamination of pond sediment and co-occurrence of metal and antibiotic resistance in Escherichia coli from Nigerian aquaculture. International Journal of Environmental Studies, 78(5), 773-784. https://doi.org/10.1080/00207233.2020.1804741

Akinbowale, O. L., Peng, H., Grant, P., & Barton, M. D. (2007). Antibiotic and heavy metal resistance in motile aeromonads and pseudomonads from rainbow trout (Oncorhynchus mykiss) farms in Australia. International Journal of Antimicrobial Agents, 30(2), 177-182. https://doi.org/10.1016/j.ijantimicag.2007.03.012

Al-Mnaser, A. A., & Woodward, M. J. (2020). Sub-lethal concentrations of phytochemicals (carvacrol and oregano) select for reduced susceptibility mutants of O23: H52 Polish Journal of Microbiology, 69(1), 121-125. https://doi.org/10.33073/pjm-2020-003

Alderton, I., Palmer, B. R., Heinemann, J. A., Pattis, I., Weaver, L., Gutiérrez-Ginés, M. J., Horswell, J., & Tremblay, L. A. (2021). The role of emerging organic contaminants in the development of antimicrobial resistance. Emerging Contaminants, 7, 160-171. https://doi.org/10.1016/j.emcon.2021.07.001

Allen, K. J., Wa?ecka-Zacharska, E., Chen, J. C., Katarzyna, K. P., Devlieghere, F., Van Meervenne, E., Osek, J., Wieczorek, K., & Bania, J. (2016). Listeria monocytogenes–An examination of food chain factors potentially contributing to antimicrobial resistance. Food Microbiology, 54, 178-189. https://doi.org/10.1016/j.fm.2014.08.006

Alonso-Hernando, A., Capita, R., Prieto, M., & Alonso-Calleja, C. (2009). Comparison of antibiotic resistance patterns in Listeria monocytogenes and Salmonella enterica strains pre-exposed and exposed to poultry decontaminants. Food Control, 20, 1108–1111. https://doi.org/10.1016/j.foodcont.2009.02.011

Álvarez-Martínez, F. J., Barrajón-Catalán, E., Herranz-López, M., & Micol, V. (2021). Antibacterial plant compounds, extracts and essential oils: An updated review on their effects and putative mechanisms of action. Phytomedicine, 90, 153626. https://doi.org/10.1016/j.phymed.2021.153626

Amachawadi, R. G., Scott, H. M., Aperce, C., Vinasco, J., Drouillard, J. S., & Nagaraja, T. G. (2015b). Effects of in-feed copper and tylosin supplementations on copper and antimicrobial resistance in faecal enterococci of feedlot cattle. Journal of Applied Microbiology, 118, 1287–1297. https://doi.org/10.1111/jam.12790

Amachawadi, R. G., Scott, H. M., Vinasco, J., Tokach, M. D., Dritz, S. S., Nelssen, J. L., & Nagaraja, T. G. (2015a). Effects of in-feed copper, chlortetracycline, and tylosin on the prevalence of transferable copper resistance gene, tcrB, among fecal enterococci of weaned piglets. Foodborne Pathogens and Disease, 12(8), 670-678. https://doi.org/10.1089/fpd.2015.1961

Amachawadi, R. G., Shelton, N. W., Jacob, M. E., Shi, X., Narayanan, S. K., Zurek, L., Dritz, S. S., Nelssen, J. L., Tokach, M. D., & Nagaraja, T. G. (2010). Occurrence of tcrB, a transferable copper resistance gene, in fecal enterococci of swine. Foodborne Pathogens and Disease, 7(9), 1089-1097. https://doi.org/10.1089/fpd.2010.0540

Amachawadi, R. G., Shelton, N. W., Shi, X., Vinasco, J., Dritz, S. S., Tokach, M. D., Nelssen, J. L., Scott, H. M., & Nagaraja, T. G. (2011). Selection of fecal enterococci exhibiting tcrB-mediated copper resistance in pigs fed diets supplemented with copper. Applied and Environmental Microbiology, 77(16), 5597-5603. https://doi.org/10.1128/AEM.00364-11

Amjad, Z. (2010). The science and technology of industrial water treatment. CRC press. https://doi.org/10.1201/9781420071450

Anand, T., Bera, B. C., Vaid, R. K., Barua, S., Riyesh, T., Virmani, N., Hussain, M., Singh, R. K., and Tripathi, B. N. (2016). Abundance of antibiotic resistance genes in environmental bacteriophages. Journal of General Virology, 97(12), 3458–66. https://doi.org/10.1099/jgv.0.000639

Anedda, E., Farrell, M. L., Morris, D., & Burgess, C. M. (2023). Evaluating the impact of heavy metals on antimicrobial resistance in the primary food production environment: A scoping review. Environmental Pollution, 121035. https://doi.org/10.1016/j.envpol.2023.121035

Aperce, C. C., Amachawadi, R., Van Bibber-Krueger, C. L., Nagaraja, T. G., Scott, H. M., Vinasco-Torre, J., & Drouillard, J. S. (2016). Effects of menthol supplementation in feedlot cattle diets on the fecal prevalence of antimicrobial-resistant Escherichia coli. PloS one, 11(12), e0168983. https://doi.org/10.1371/journal.pone.0168983

Argudín, M. A., Lauzat, B., Kraushaar, B., Alba, P., Agerso, Y., Cavaco, L., Butaye, P., Concepción Porrero, M., Battisti, A., Tenhagen, B.-A., Fetsch, A., & Guerra, B. (2016). Heavy metal and disinfectant resistance genes among livestock-associated methicillin-resistant Staphylococcus aureus isolates. Veterinary Microbiology, 191, 88-95. https://doi.org/10.1016/j.vetmic.2016.06.004

Arya, S., Williams, A., Reina, S. V., Knapp, C. W., Kreft, J. U., Hobman, J. L., & Stekel, D. J. (2021). Towards a general model for predicting minimal metal concentrations co-selecting for antibiotic resistance plasmids. Environmental Pollution, 275, 116602. https://doi.org/10.1016/j.envpol.2021.116602

Bassani, J., Paravisi, M., Wilsmann, D. E., Borges, K. A., Furian, T. Q., Salle, C. T., Moraes, L. S., & Nascimento, V. P. (2021). Antimicrobial and disinfectant resistance of Salmonella Heidelberg from Brazilian flocks did not increase for ten years (2006-2016). Pesquisa Veterinária Brasileira, 41, e06818. https://doi.org/10.1590/1678-5150-PVB-6818

Becerril, R., Nerin, C., & Gomez-Lus, R. (2012). Evaluation of bacterial resistance to essential oils and antibiotics after exposure to oregano and cinnamon essential oils. Foodborne Pathogens and Disease, 9, 699–705. https://doi.org/10.1089/fpd.2011.1097

Bednorz, C., Oelgeschlaeger, K., Kinnemann, B., Hartmann, S., Neumann, K., Pieper, R., Bethe, A., Semmler, T., Tedin, K., Schierack, P., Wieler, L. H., & Guenther, S. (2013). The broader context of antibiotic resistance: Zinc feed supplementation of piglets increases the proportion of multi-resistant Escherichia coli in vivo. International Journal of Medical Microbiology, 303, 396–403. https://doi.org/10.1016/j.ijmm.2013.06.004

Beier, R. C., Anderson, P. N., Hume, M. E., Poole, T. L., Duke, S. E., Crippen, T. L., Sheffield, C. L., Caldwell, D. J., Byrd, J. A., Anderson, R. C., & Nisbet, D. J. (2011). Characterization of salmonella enterica isolates from turkeys in commercial processing plants for resistance to antibiotics, disinfectants, and a growth promoter. Foodborne Pathogens and Disease, 8(5), 593–600. https://doi.org/10.1089/fpd.2010.0702

Beier, R. C., Byrd, J. A., Andrews, K., Caldwell, D., Crippen, T. L., Anderson, R. C., & Nisbet, D. J. (2021). Disinfectant and antimicrobial susceptibility studies of the foodborne pathogen Campylobacter jejuni isolated from the litter of broiler chicken houses. Poultry Science, 100(2), 1024-1033. https://doi.org/10.1016/j.psj.2020.10.045

Beier, R. C., Harvey, R. B., Hernandez, C. A., Andrews, K., Droleskey, R. E., Hume, M. E., Davidson, M. K., Bodeis-Jones, S., Young, S., Anderson, R. C., & Nisbet, D. J. (2019). Disinfectant and antimicrobial susceptibility profiles of Campylobacter coli isolated in 1998 to 1999 and 2015 from swine and commercial pork chops. Journal of Food Science, 84(6), 1501-1512. https://doi.org/10.1111/1750-3841.14622

Beier, R. C., Poole, T. L., Brichta-Harhay, D. M., Anderson, R. C., Bischoff, K. M., Hernandez, C. A., Bono, J. L., Arthur, T. M., Nagaraja, T. G., Crippen, T. L., Sheffield, C. L., & Nisbet, D. J. (2013). Disinfectant and antibiotic susceptibility profiles of Escherichia coli O157: H7 strains from cattle carcasses, feces, and hides and ground beef from the United States. Journal of Food Protection, 76(1), 6-17. https://doi.org/10.4315/0362-028X.JFP-12-253

Bell, N. J., Potterton, S., Blowey, R., Whay, H. R., & Huxley, J. N. (2014). Disinfectant footbathing agents for the control of bovine digital dermatitis in dairy cattle. Livestock, 19(1), 6-13. https://doi.org/10.12968/live.2014.19.1.6

Bengtsson-Palme, J. (2017). Antibiotic resistance in the food supply chain: where can sequencing and metagenomics aid risk assessment? Current Opinion in Food Science, 14, 66-71. https://doi.org/10.1016/j.cofs.2017.01.010

Bennett, P. M. (2008). Plasmid encoded antibiotic resistance: acquisition and transfer of antibiotic resistance genes in bacteria. British Journal of Pharmacology, 153(S1) S347-S357. https://doi.org/10.1038/sj.bjp.0707607

Bennett, P. M., Livesey, C. T., Nathwani, D., Reeves, D. S., Saunders, J. R., & Wise, R. (2004). An assessment of the risks associated with the use of antibiotic resistance genes in genetically modified plants: report of the Working Party of the British Society for Antimicrobial Chemotherapy. Journal of Antimicrobial Chemotherapy, 53(3), 418-431. https://doi.org/10.1093/jac/dkh087

Bloomfield, S. F. (2002). Significance of biocide usage and antimicrobial resistance in domiciliary environments. Journal of Applied Microbiology, 92, 144S-157S. https://doi.org/10.1046/j.1365-2672.92.5s1.15.x

Bridier, A., Le Grandois, P., Moreau, M. H., Prénom, C., Le Roux, A., Feurer, C., & Soumet, C. (2019). Impact of cleaning and disinfection procedures on microbial ecology and Salmonella antimicrobial resistance in a pig slaughterhouse. Scientific Reports, 9(1), 1-13. https://doi.org/10.1038/s41598-019-49464-8

Burridge, L., Weis, J. S., Cabello, F., Pizarro, J., & Bostick, K. (2010). Chemical use in salmon aquaculture: a review of current practices and possible environmental effects. Aquaculture, 306(1-4), 7-23. https://doi.org/10.1016/j.aquaculture.2010.05.020

Buta, M., Korzeniewska, E., Harnisz, M., Hubeny, J., Zieli?ski, W., Rolbiecki, D.,

Bajkacz, S., Felis, E., & Kokoszka, K. (2021). Microbial and chemical pollutants on the manure-crops pathway in the perspective of “One Health” holistic approach. Science of the Total Environment, 785, 147411. https://doi.org/10.1016/j.scitotenv.2021.147411

Cabello, F. C., Godfrey, H. P., Buschmann, A. H., & Dölz, H. J. (2016). Aquaculture as yet another environmental gateway to the development and globalisation of antimicrobial resistance. The Lancet Infectious Diseases, 16(7), e127-e133. https://doi.org/10.1016/S1473-3099(16)00100-6

Capita, R., & Alonso-Calleja, C. (2013). Antibiotic-resistant bacteria: a challenge for the food industry. Critical Reviews in Food Science and Nutrition, 53(1), 11-48. https://doi.org/10.1080/10408398.2010.519837

Capita, R., Álvarez-Fernández, E., Fernández-Buelta, E., Manteca, J., & Alonso Calleja, C. (2013). Decontamination treatments can increase the prevalence of resistance to antibiotics of Escherichia coli naturally present on poultry. Food Microbiology, 34(1), 112-117. http://dx.doi.org/10.1016/j.fm.2012.11.011

Carattoli, A. (2001). Importance of integrons in the diffusion of resistance. Veterinary Research, 32(3-4), 243-259. https://doi.org/10.1051/vetres:2001122
Caruana, J. C., & Walper, S. A. (2020). Bacterial membrane vesicles as mediators of microbe–microbe and microbe–host community interactions. Frontiers in Microbiology, 11, 432. https://doi.org/10.3389/fmicb.2020.00432

Cavaco, L. M., Hasman, H., & Aarestrup, F. M. (2011). Zinc resistance of Staphylococcus aureus of animal origin is strongly associated with methicillin resistance. Veterinary Microbiology, 150(3-4), 344-348. https://doi.org/10.1016/j.vetmic.2011.02.014

Cavaco, L. M., Hasman, H., Stegger, M., Andersen, P. S., Skov, R., Fluit, A. C., Ito, T., & Aarestrup, F. M. (2010). Cloning and occurrence of czrC, a gene conferring cadmium and zinc resistance in methicillin-resistant Staphylococcus aureus CC398 isolates. Antimicrobial Agents and Chemotherapy, 54(9), 3605-3608. https://doi.org/10.1128/AAC.00058-10

Cheng, G., Ning, J., Ahmed, S., Huang, J., Ullah, R., An, B., Hao, H., Dai, M., Huang, L., Wang, X., & Yuan, Z. (2019). Selection and dissemination of antimicrobial resistance in Agri-food production. Antimicrobial Resistance & Infection Control, 8(1), 1-13.

https://doi.org/10.1186/s13756-019-0623-2

Chenia, H. Y., & Jacobs, A. (2017). Antimicrobial resistance, heavy metal resistance and integron content in bacteria isolated from a South African tilapia aquaculture system. Diseases of Aquatic Organisms, 126(3), 199-209. https://doi.org/10.3354/dao03173

Chuanchuen, R., Pathanasophon, P., Khemtong, S., Wannaprasat, W., & Padungtod, P. (2008). Susceptibilities to antimicrobials and disinfectants in Salmonella isolates obtained from poultry and swine in Thailand. Journal of Veterinary Medical Science, 70(6), 595-601. https://doi.org/10.1292/jvms.70.595

Ciesinski, L., Guenther, S., Pieper, R., Kalisch, M., Bednorz, C., & Wieler, L. H. (2018). High dietary zinc feeding promotes persistence of multi-resistant E. coli in the swine gut. PLoS One, 13(1), e0191660. https://doi.org/10.1371/journal.pone.0191660

Ciric, L., Mullany, P., & Roberts, A. P. (2011). Antibiotic and antiseptic resistance genes are linked on a novel mobile genetic element: Tn 6087. Journal of Antimicrobial Chemotherapy, 66(10), 2235-2239. https://doi.org/10.1093/jac/dkr311

Cogliani, C., Goossens, H., & Greko, C. (2011). Restricting antimicrobial use in food animals: Lessons from Europe. Microbe, 6(6), 274–279. https://doi.org/10.1128/microbe.6.274.1

Colavecchio, A., Cadieux, B., Lo, A., & Goodridge, L. D. (2017). Bacteriophages contribute to the spread of antibiotic resistance genes among foodborne pathogens of the Enterobacteriaceae family–a review. Frontiers in Microbiology, 8, 1108. https://doi.org/10.3389/fmicb.2017.01108

Cufaoglu, G., Cengiz, G., Acar, B., Yesilkaya, B., Ayaz, N. D., Levent, G., & Goncuoglu, M. (2022). Antibiotic, heavy metal, and disinfectant resistance in chicken, cattle, and sheep origin E. coli and whole?genome sequencing analysis of a multidrug?resistant E. coli O100:H25 strain. Journal of Food Safety, 42(5), e12995. https://doi.org/10.1111/jfs.12995

Davies, R., & Wales, A. (2019). Antimicrobial resistance on farms: a review including biosecurity and the potential role of disinfectants in resistance selection. Comprehensive Reviews in Food Science and Food Safety, 18(3), 753-774. https://doi.org/10.1111/1541-4337.12438

de Souza, E. L. (2016). The effects of sublethal doses of essential oils and their constituents on antimicrobial susceptibility and antibiotic resistance among food-related bacteria: A review. Trends in Food Science & Technology, 56, 1-12. http://dx.doi.org/10.1016/j.tifs.2016.07.012

De?bski, B. (2016). Supplementation of pigs diet with zinc and copper as alternative to conventional antimicrobials. Polish Journal of Veterinary Sciences, 19(4). https://doi.org/10.1515/pjvs-2016-0113

Denyer, S. P., & Maillard, J. Y. (2002). Cellular impermeability and uptake of biocides and antibiotics in Gram?negative bacteria. Journal of Applied Microbiology, 92(s1), 35S-45S. https://doi.org/10.1046/j.1365-2672.92.5s1.19.x

Diard, M., Bakkeren, E., Cornuault, J. K., Moor, K., Hausmann, A., Sellin, M. E., Loverdo, C., Aertsen, A., Ackermann, M, de Papepe, M., Slack, E., & Hardt, W. D. (2017). Inflammation boosts bacteriophage transfer between Salmonella spp. Science 355, 1211–1215. https://doi.org/10.1126/science.aaf8451

Donaghy, J. A., Jagadeesan, B., Goodburn, K., Grunwald, L., Jensen, O. N., Jespers, A. D., Kanagachandran, K., Lafforgue, H., Seefelder, W., & Quentin, M. C. (2019). Relationship of sanitizers, disinfectants, and cleaning agents with antimicrobial resistance. Journal of Food Protection, 82(5), 889-902. https://doi.org/10.4315/0362-028X.JFP-18-373

Dong, Z., Wang, J., Wang, L., Zhu, L., Wang, J., Zhao, X., & Kim, Y. M. (2022). Distribution of quinolone and macrolide resistance genes and their co-occurrence with heavy metal resistance genes in vegetable soils with long-term application of manure. Environmental Geochemistry and Health, 44(10), 3343-3358. https://doi.org/10.1007/s10653-021-01102-x

Duan, M., Gu, J., Wang, X., Li, Y., Zhang, R., Hu, T., & Zhou, B. (2019). Factors that affect the occurrence and distribution of antibiotic resistance genes in soils from livestock and poultry farms. Ecotoxicology and Environmental Safety, 180, 114-122. https://doi.org/10.1016/j.ecoenv.2019.05.005

Dweba, C. C., Zishiri, O. T., & El Zowalaty, M. E. (2018). Methicillin-resistant Staphylococcus aureus: livestock-associated, antimicrobial, and heavy metal resistance. Infection and Drug Resistance, 11, 2497. https://doi.org/10.2147/IDR.S175967

EFSA BIOHAZ Panel (EFSA Panel on Biological Hazards) (2008). Assessment of the possible effect of the four antimicrobial treatment substances on the emergence of antimicrobial resistance. EFSA Journal, 659, https://doi.org/10.2903/j.efsa.2008.659

EFSA BIOHAZ Panel (EFSA Panel on Biological Hazards) (2021). Scientific Opinion on the role played by the environment in the emergence and spread of antimicrobial resistance (AMR) through the food chain. EFSA Journal,19(6):6651, 188 pp. https://doi.org/10.2903/j.efsa.2021.6651

EFSA FEEDAP Panel (EFSA Panel on Additives and Products or Substances used in Animal Feed) (2014). Scientific opinion on the potential reduction of the currently authorised maximum zinc content in complete feed. EFSA Journal,12(5):3668, 77 pp. https://doi.org/10.2903/j.efsa.2014.3668

EFSA FEEDAP Panel (EFSA Panel on Additives and Products or Substances used in Animal Feed) (2016). Scientific opinion on the revision of the currently authorised maximum copper content in complete feed. EFSA Journal, 14(8):4563, 100 pp. https://doi.org/10.2903/j.efsa.2016.4563

Ejileugha, C. (2022). Biochar can mitigate co-selection and control antibiotic resistant genes (ARGs) in compost and soil. Heliyon, e09543. https://doi.org/10.1016/j.heliyon.2022.e09543

El Behiry, A., Schlenker, G., Szabo, I., & Roesler, U. (2012). In vitro susceptibility of Staphylococcus aureus strains isolated from cows with subclinical mastitis to different antimicrobial agents. Journal of Veterinary Science, 13(2), 153-161. https://doi.org/10.4142/jvs.2012.13.2.153

Elbehiry, A., Al?Dubaib, M., Marzouk, E., & Moussa, I. (2019). Antibacterial effects and resistance induction of silver and gold nanoparticles against Staphylococcus aureus?induced mastitis and the potential toxicity in rats. MicrobiologyOpen, 8(4), e00698. https://doi.org/10.1002/mbo3.698

EMA & EFSA (European Medicines Agency and European Food Safety Authority) (2017). EMA and EFSA Joint Scientific Opinion on measures to reduce the need to use antimicrobial agents in animal husbandry in the European Union, and the resulting impacts on food safety (RONAFA). [EMA/CVMP/570771/2015]. EFSA Journal, 15(1):4666, 245 pp. https://doi.org/10.2903/j.efsa. 2017.4666

Eom, H. S., Back, S. H., Lee, H. H., Lee, G. Y., & Yang, S. J. (2019). Prevalence and characteristics of livestock-associated methicillin-susceptible Staphylococcus aureus in the pork production chain in Korea. Journal of Veterinary Science, 20(6), e69. https://doi.org/10.4142/jvs.2019.20.e69

Ezugworie, F. N., Igbokwe, V. C., & Onwosi, C. O. (2021). Proliferation of antibiotic-resistant microorganisms and associated genes during composting: An overview of the potential impacts on public health, management and future. Science of The Total Environment, 784, 147191. https://doi.org/10.1016/j.scitotenv.2021.147191

Fadli, M., Chevalier, J., Hassani, L., Mezrioui, N. E., & Pages, J. M. (2014). Natural extracts stimulate membrane-associated mechanisms of resistance in Gram-negative bacteria. Letters in Applied Microbiology, 58, 472–477. https://doi.org/10.1111/lam.12216

Fang, L., Li, X., Li, L., Li, S., Liao, X., Sun, J., & Liu, Y. (2016). Co-spread of metal and antibiotic resistance within ST3-IncHI2 plasmids from E. coli isolates of food-producing animals. Scientific Reports, 6(1), 1-8. https://doi.org/10.1038/srep25312.
FAO/WHO (2019). Joint FAO/WHO Expert Meeting in Collaboration with OIE on Foodborne Antimicrobial Resistance: Role of the Environment. Crops and Biocides. Microbiological Risk Assessment Series no. 34, Rome. (Last accessed: February 2023)

Ferreira, J. C., Penha Filho, R. A. C., Andrade, L. N., & Darini, A. L. C. (2019). Evaluation of heavy metal tolerance genes in plasmids harbored in multidrug-resistant Salmonella enterica and Escherichia coli isolated from poultry in Brazil. Diagnostic Microbiology and Infectious Disease, 94(3), 314-315. https://doi.org/10.1016/j.diagmicrobio.2019.01.019

Feßler, A. T., Zhao, Q., Schoenfelder, S., Kadlec, K., Michael, G. B., Wang, Y., Ziebuhr, W., Shen, J., & Schwarz, S. (2017). Complete sequence of a plasmid from a bovine methicillin-resistant Staphylococcus aureus harbouring a novel ica-like gene cluster in addition to antimicrobial and heavy metal resistance genes. Veterinary Microbiology, 200, 95-100. https://doi.org/10.1016/j.vetmic.2016.07.010

Food Standards Agency (2016). Chief Scientific Adviser’s Science Report, Issue four: Antimicrobial resistance in the food supply chain. Food Standards Agency. (Last accessed: December 2022)

Galetti, R., Penha Filho, R. A. C., Ferreira, J. C., Varani, A. M., & Darini, A. L. C. (2019). Antibiotic resistance and heavy metal tolerance plasmids: The antimicrobial bulletproof properties of Escherichia fergusonii isolated from poultry. Infection and Drug Resistance, 12, 1029-1033. https://doi.org/10.2147/IDR.S196411

Galetti, R., Penha Filho, R. A. C., Ferreira, J. C., Varani, A. M., Sazinas, P., Jelsbak, L., & Darini, A. L. C. (2021). The plasmidome of multidrug-resistant emergent Salmonella serovars isolated from poultry. Infection, Genetics and Evolution, 89, 104716. https://doi.org/10.1016/j.meegid.2021.104716

Gantzhorn, M. R., Pedersen,K., Olsen, J. E., & Thomsen, L. E. (2014). Biocide and antibiotic susceptibility of Salmonella isolates obtained before and after cleaning at six Danish pig slaughterhouses. International Journal of Food Microbiology, 181, 53–59. https://doi.org/10.1016/j.ijfoodmicro.2014.04.021

Geueke, B. (2014). Dossier – Biocides and food contact materials. Food Packaging Forum. (Last accessed: April 2023)

Ghazisaeedi, F., Ciesinski, L., Bednorz, C., Johanns, V., Pieper, L., Tedin, K., Wieler, L. H., & Günther, S. (2020). Phenotypic zinc resistance does not correlate with antimicrobial multi-resistance in fecal E. coli isolates of piglets. Gut pathogens, 12(1), 1-10. https://doi.org/10.1186/s13099-019-0342-5

Giacometti, F., Shirzad-Aski, H., & Ferreira, S. (2021). Antimicrobials and food-related stresses as selective factors for antibiotic resistance along the farm to fork continuum. Antibiotics, 10(6),

671. https://doi.org/10.3390/antibiotics10060671

Gomez-Sanz, E., Kadlec, K., Fessler, A. T., Zarazaga, M., Torres, C., & Schwarz, S. (2013). Novel erm(T)-carrying multiresistance plasmids from porcine and human isolates of methicillin-resistant Staphylococcus aureus ST398 that also harbor cadmium and copper resistance determinants. Antimicrobial Agents and Chemotherapy, 57(7), 3275–3282. https://doi.org/10.1128/AAC.00171-13

Guardiola, F. A., Cuesta, A., Meseguer, J., & Esteban, M. A. (2012). Risks of using antifouling biocides in aquaculture. International Journal of Molecular Sciences, 13(2), 1541-1560. https://doi.org/10.3390/ijms13021541

Gullberg, E., Albrecht, L. M., Karlsson, C., Sandegren, L., & Andersson, D. I. (2014). Selection of a multidrug resistance plasmid by sublethal levels of antibiotics and heavy metals. MBio, 5(5), e01918-14. https://doi.org/10.1128/mBio.01918-14

Guo, T., Lou, C. L., Zhai, W. W., Tang, X. J., Hashmi, M. Z., Murtaza, R., Li, Y., Liu, X. M., & Xu, J. M. (2018). Increased occurrence of heavy metals, antibiotics and resistance genes in surface soil after long-term application of manure. The Science of the Total Environment, 635, 995–1003. https://doi.org/10.1016/j.scitotenv.2018.04.194

Haley, B. J., Kim, S. J., Biswas, D., Hovingh, E., & Van Kessel, J. A. S. (2022). Virulome and genome analyses identify associations between antimicrobial resistance genes and virulence factors in highly drug-resistant Escherichia coli isolated from veal calves. PLOS ONE, 17(3), e0265445. https://doi.org/10.1371/journal.pone.0265445

Hall, J. P., Brockhurst, M. A., & Harrison, E. (2017). Sampling the mobile gene pool: innovation via horizontal gene transfer in bacteria. Philosophical Transactions of the Royal Society B: Biological Sciences, 372(1735), 20160424. https://doi.org/10.1098/rstb.2016.0424

Hall, J. P., Wright, R. C., Guymer, D., Harrison, E., & Brockhurst, M. A. (2020). Extremely fast amelioration of plasmid fitness costs by multiple functionally diverse pathways. Microbiology, 166(1), 56-62. https://doi.org/10.1099/mic.0.000862

Hall, J. P., Wright, R. C., Harrison, E., Muddiman, K. J., Wood, A. J., Paterson, S., & Brockhurst, M. A. (2021). Plasmid fitness costs are caused by specific genetic conflicts enabling resolution by compensatory mutation. PLoS biology, 19(10), e3001225. https://doi.org/10.1371/journal.pbio.3001225

Hasman, H., & Aarestrup, F. M. (2002). tcrB a gene conferring transferable copper resistance in Enterococcus faecium: Occurrence, transferability, and linkage to macrolide and glycopeptide resistance. Antimicrobial Agents and Chemotherapy, 46, 1410–1416. https://doi.org/10.1128/AAC.46.5.1410-1416.2002

Hasman, H., Kempf, I., Chidaine, B., Cariolet, R., Ersbøll, A. K., Houe, H., Hansen, H. C. B., & Aarestrup, F. M. (2006). Copper resistance in Enterococcus faecium, mediated by the tcrB gene, is selected by supplementation of pig feed with copper sulfate. Applied and Environmental Microbiology, 72(9), 5784-5789. https://doi.org/10.1128/AEM.02979-05

Hau, S. J., Frana, T., Sun, J., Davies, P. R., & Nicholson, T. L. (2017). Zinc resistance within swine-associated methicillin-resistant Staphylococcus aureus isolates in the United States is associated with multilocus sequence type lineage. Applied and Environmental Microbiology, 83, 1–9. https://doi.org/10.1128/AEM.00756-17

Hegstad, K., Langsrud, S., Lunestad, B. T., Scheie, A. A., Sunde, M., & Yazdankhah, S. P. (2010). Does the wide use of quaternary ammonium compounds enhance the selection and spread of antimicrobial resistance and thus threaten our health? Microbial Drug Resistance, 16(2), 91-104. https://doi.org/10.1089/mdr.2009.0120

Hejna, M., Gottardo, D., Baldi, A., Dell'Orto, V., Cheli, F., Zaninelli, M., & Rossi, L. (2018). Review: Nutritional ecology of heavy metals. Animal, 12(10), 2156-2170. https://doi.org/10.1017/S175173111700355X

Hölzel, C. S., Müller, C., Harms, K. S., Mikolajewski, S., Schäfer, S., Schwaiger, K., & Bauer, J. (2012). Heavy metals in liquid pig manure in light of bacterial antimicrobial resistance. Environmental Research, 113, 21-27. https://doi.org/10.1016/j.envres.2012.01.002

Hölzel, C. S., Tetens, J. L., & Schwaiger, K. (2018). Unraveling the role of vegetables in spreading antimicrobial-resistant bacteria: a need for quantitative risk assessment. Foodborne Pathogens and Disease. 15(11), 671-688. https://doi.org/10.1089/fpd.2018.2501

Hu, Y., Jiang, L., Zhang, T., Jin, L., Han, Q., Zhang, D., Lin, K., & Cui, C. (2018). Occurrence and removal of sulfonamide antibiotics and antibiotic resistance genes in conventional and advanced drinking water treatment processes. Journal of Hazardous Materials, 360, 364-372. https://doi.org/10.1016/j.jhazmat.2018.08.012

Huddleston, J. R. (2014). Horizontal gene transfer in the human gastrointestinal tract: potential spread of antibiotic resistance genes. Infection and Drug Resistance, 7, 167. https://doi.org/10.2147/IDR.S48820

Jacob, M. E., Fox, J. T., Nagaraja, T. G., Drouillard, J. S., Amachawadi, R. G., & Narayanan, S. K. (2010). Effects of feeding elevated concentrations of copper and zinc on the antimicrobial susceptibilities of fecal bacteria in feedlot cattle. Foodborne Pathogens and Disease, 7(6), 643-648. https://doi.org/10.1089/fpd.2009.0401

James, C., Dixon, R., Talbot, L., James, S. J., Williams, N., & Onarinde, B. A. (2021). Assessing the impact of heat treatment of food on antimicrobial resistance genes and their potential uptake by other bacteria - A critical review. Antibiotics, 10(12) p1440. https://doi.org/10.3390/antibiotics10121440

Jebri, S., Rahmani, F., & Hmaied, F. (2021). Bacteriophages as antibiotic resistance genes carriers in agro?food systems. Journal of Applied Microbiology, 130(3), 688-698. https://doi.org/10.1111/jam.14851

Jensen, J., Kyvsgaard, N. C., Battisti, A., & Baptiste, K. E. (2018). Environmental and public health related risk of veterinary zinc in pig production-using Denmark as an example. Environment International, 114, 181-190. https://doi.org/10.1016/j.envint.2018.02.007

Ji, X., Shen, Q., Liu, F., Ma, J., Xu, G., Wang, Y., & Wu, M. (2012). Antibiotic resistance gene abundances associated with antibiotics and heavy metals in animal manures and agricultural soils adjacent to feedlots in Shanghai; China. Journal of Hazardous Materials, 235, 178-185. https://doi.org/10.1016/j.jhazmat.2012.07.040

Jones, I. A., & Joshi, L. T. (2021). Biocide use in the antimicrobial era: A review. Molecules, 26(8), 2276. https://doi.org/10.3390/molecules26082276

Jutkina, J., Marathe, N. P., Flach, C.-F., & Larsson, D. G. J. (2018). Antibiotics and common antibacterial biocides stimulate horizontal transfer of resistance at low concentrations. Science of the Total Environment, 616–617, 172–178. https://doi.org/10.1016/j.scitotenv.2017.10.312

Kampf, G. (2018). Biocidal agents used for disinfection can enhance antibiotic resistance in gram-negative species. Antibiotics, 7(4), 110. https://doi.org/10.3390/antibiotics7040110

Kampf, G. (2019). Antibiotic resistance can be enhanced in Gram-positive species by some biocidal agents used for disinfection. Antibiotics, 8(1), 13. https://doi.org/10.3390/antibiotics8010013

Klümper, U., Recker, M., Zhang, L., Yin, X., Zhang, T., Buckling, A., & Gaze, W. H. (2019). Selection for antimicrobial resistance is reduced when embedded in a natural microbial community. The ISME journal, 13(12), 2927-2937. https://doi.org/10.1038/s41396-019-0483-z

Kotb, S., & Sayed, M. (2015). Sensitivity of methicillin-resistance and methicillin-susceptible Staphylococcus aureus strains to some different disinfectants. International Journal of Livestock Research, 5(8), 45–58. https://doi.org/10.5455/ijlr.20150822031340

Kulkarni, H. M., Nagaraj, R., & Jagannadham, M. V. (2015). Protective role of E. coli outer membrane vesicles against antibiotics. Microbiological Research, 181, 1-7. https://doi.org/10.1016/j.micres.2015.07.008

Langsrud, S., Møretrø, T., & Sundheim, G. (2003). Characterization of Serratia marcescens surviving in disinfecting footbaths. Journal of Applied Microbiology, 95(1), 186-195. https://doi.org/10.1046/j.1365-2672.2003.01968.x

Le Devendec, L., Jouy, E., & Kempf, I. (2018). Evaluation of resistance gene transfer from heat-treated Escherichia coli. International Journal of Food Microbiology, 270, 39-43. https://doi.org/10.1016/j.ijfoodmicro.2018.02.019

Lemire, J. A., Harrison, J. J., & Turner, R. J. (2013). Antimicrobial activity of metals: mechanisms, molecular targets and applications. Nature Reviews Microbiology, 11(6), 371-384. https://doi.org/10.1038/nrmicro3028

Li, C., Quan, Q., Gan, Y., Dong, J., Fang, J., Wang, L., & Liu, J. (2020). Effects of heavy metals on microbial communities in sediments and establishment of bioindicators based on microbial taxa and function for environmental monitoring and management. Science of the Total Environment, 749, 141555. https://doi.org/10.1016/j.scitotenv.2020.141555

Li, N., Chen, J., Liu, C., Yang, J., Zhu, C., & Li, H. (2022c). Cu and Zn exert a greater influence on antibiotic resistance and its transfer than doxycycline in agricultural soils. Journal of Hazardous Materials, 423, 127042. https://doi.org/10.1016/j.jhazmat.2021.127042

Li, N., Li, H., Zhu, C., Liu, C., Su, G., & Chen, J. (2022a). Controlling AMR in the pig industry: Is it enough to restrict heavy metals?. International Journal of Environmental Research and Public Health, 19(18), 11265. https://doi.org/10.3390/ijerph191811265

Li, Y., Liu, B., Zhang, X., Gao, M., & Wang, J. (2015). Effects of Cu exposure on enzyme activities and selection for microbial tolerances during swine-manure composting. Journal of Hazardous Materials, 283, 512-518. https://doi.org/10.1016/j.jhazmat.2014.09.061

Li, Z., Junaid, M., Chen, G., & Wang, J. (2022b). Interactions and associated resistance development mechanisms between microplastics, antibiotics and heavy metals in the aquaculture environment. Reviews in Aquaculture, 14(2), 1028-1045. https://doi.org/10.1111/raq.12639

Likotrafiti, E., Oniciuc, E. A., Prieto, M., Santos, J. A., López, S., & Alvarez?Ordóñez, A. (2018). Risk assessment of antimicrobial resistance along the food chain through culture?independent methodologies. EFSA Journal, 16(S1), e160811. https://doi.org/10.2903/j.efsa.2018.e160811

Liu, B., Yu, K., Ahmed, I., Gin, K., Xi, B., Wei, Z., He, Y., & Zhang, B. (2021a). Key factors driving the fate of antibiotic resistance genes and controlling strategies during aerobic composting of animal manure: A review. Science of the Total Environment, 791, 148372. https://doi.org/10.1016/j.scitotenv.2021.148372

Liu, C., Li, G., Qin, X., Xu, Y., Wang, J., Wu, G., Feng, H., Ye, J., Zhu, C., Li, X., & Zheng, X. (2022). Profiles of antibiotic-and heavy metal-related resistance genes in animal manure revealed using a metagenomic analysis. Ecotoxicology and Environmental Safety, 239, 113655. https://doi.org/10.1016/j.ecoenv.2022.113655

Liu, C., Li, X., Zheng, S., Kai, Z., Jin, T., Shi, R., Huang, H., & Zheng, X. (2021b). Effects of wastewater treatment and manure application on the dissemination of antimicrobial resistance around swine feedlots. Journal of Cleaner Production, 280, 123794. https://doi.org/10.1016/j.jclepro.2020.123794

Liwa, A., & Jaka, H. M. (2015). Antimicrobial resistance: Mechanisms of action of antimicrobial agents. In: The Battle Against Microbial Pathogens: Basic Science, Technological Advances and Educational Programs, A. Méndez-Vilas (Ed), Vol. 1, 876-885. (Last accessed: April 2023)

Lorenz, M. G., & Wackernagel, W. (1994). Bacterial gene transfer by natural genetic transformation in the environment. Microbiological Reviews, 58(3), 563-602. https://doi.org/10.1128/mr.58.3.563-602.1994.

Maertens, H., De Reu, K., Meyer, E., Van Coillie, E., & Dewulf, J. (2019). Limited association between disinfectant use and either antibiotic or disinfectant susceptibility of Escherichia coli in both poultry and pig husbandry. BMC Veterinary Research, 15(1), 1-12. https://doi.org/10.1186/s12917-019-2044-0

Maertens, H., De Reu, K., Meyer, E., Van Weyenberg, S., Dewulf, J., & Van Coillie, E. (2019). Exposure of ciprofloxacin-resistant Escherichia coli broiler isolates to subinhibitory concentrations of a quaternary ammonium compound does not increase antibiotic resistance gene transfer. Poultry Science, 98(7), 2972-2976. http://dx.doi.org/10.3382/ps/pez185

Maertens, H., Van Coillie, E., Millet, S., Van Weyenberg, S., Sleeckx, N., Meyer, E., Zoons, J., Dewulf, J., & De Reu, K. (2020). Repeated disinfectant use in broiler houses and pig nursery units does not affect disinfectant and antibiotic susceptibility in Escherichia coli field isolates. BMC Veterinary Research, 16, 1-11. https://doi.org/10.1186/s12917-020-02342-2

Maillard, J. Y. (2018). Resistance of bacteria to biocides. Microbiology Spectrum, 6(2), ARBA-0006-2017. https://doi.org/10.1128 /microbiolspec.ARBA-0006-2017

Maillard, J. Y. (2020). Bacterial resistance to biocides. In: McDonnell, G. and Hansen, J. (Eds) Blocks' Disinfection, Sterilization and Preservation, 6th edn. Philadelphia: Wolters Kluwer. (Last accessed: April 2023)

Maillard, J. Y., & Hartemann, P. (2013). Silver as an antimicrobial: facts and gaps in knowledge. Critical Reviews in Microbiology, 39(4), 373-383. https://doi.org/10.3109/1040841X.2012.713323

Mariotti, M., Lombardini, G., Rizzo, S., Scarafile, D., Modesto, M., Truzzi, E., Benvenuti, S., Elmi, A., Bertocchi, M., Fiorentini, L., Gambi, L., Scozzoli, M., & Mattarelli, P. (2022). Potential applications of essential oils for environmental sanitization and antimicrobial treatment of intensive livestock infections. Microorganisms, 10(4), 822. https://doi.org/10.3390/microorganisms10040822

Mavri, A., Kurin?i?, M., & Možina, S. S. (2012). The prevalence of antibiotic and biocide resistance among Campylobacter coli and Campylobacter jejuni from different sources. Food Technology & Biotechnology, 50(3), 371-376. (Last accessed: February 2023)

Mazhar, S. H., Li, X., Rashid, A., Su, J., Xu, J., Brejnrod, A. D., Su, J., Wu, Y., Zhu, Y., Zhou, S., Feng, R., & Rensing, C. (2021). Co-selection of antibiotic resistance genes, and mobile genetic elements in the presence of heavy metals in poultry farm environments. Science of the Total

Environment, 755, 142702. https://doi.org/10.1016/j.scitotenv.2020.142702

McDonnell, G., & Russell, A. D. (1999). Antiseptics and disinfectants: activity, action, and resistance. Clinical Microbiology Reviews, 12(1), 147-179. https://doi.org/10.1128/CMR.12.1.147

McMahon, M. A. S., Blair, I. S., Moore, J. E., & McDowell, D. A. (2007b). Habituation to sub-lethal concentrations of tea tree oil (Melaleuca alternifolia) is associated with reduced susceptibility to antibiotics in human pathogens. Journal of Antimicrobial Chemotherapy, 59, 125–127. https://doi.org/10.1093/jac/dkl443

McMahon, M. A. S., Xu, J., Moore, J. E., Blair, I. S., & McDowell, D. A. (2007a). Environmental stress and antibiotic resistance in food-related pathogens. Applied Environmental Microbiology, 73, 211–217. https://doi.org/10.1128/AEM.00578-06

Medardus, J. J., Molla, B. Z., Nicol, M., Morrow, W. M., Rajala-Schultz, P. J., Kazwala, R., & Gebreyes, W. A. (2014). In-feed use of heavy metal micronutrients in US swine production systems and its role in persistence of multidrug-resistant salmonellae. Applied and Environmental Microbiology, 80(7), 2317-2325. https://doi.org/10.1128/AEM.04283-13

Molina-Gonzalez, D., Alonso-Calleja, C., Alonso-Hernando, A., & Capita, R. (2014). Effect of sub-lethal concentrations of biocides on the susceptibility to antibiotics of multi-drug resistant Salmonella enterica strains. Food Control, 40, 329-334. http://dx.doi.org/10.1016/j.foodcont.2013.11.046

Montagnin, C., Cawthraw, S., Ring, I., Ostanello, F., Smith, R. P., Davies, R., & Martelli, F. (2022). Efficacy of five disinfectant products commonly used in pig herds against a panel of bacteria sensitive and resistant to selected antimicrobials. Animals, 12(20), 2780. https://doi.org/10.3390/ani12202780

Mozaheb, N., & Mingeot-Leclercq, M. P. (2020). Membrane vesicle production as a bacterial defense against stress. Frontiers in Microbiology, 11, 600221. https://doi.org/10.3389/fmicb.2020.600221

Mulder, I., Siemens, J., Sentek, V., Amelung, W., Smalla, K., & Jechalke, S. (2018). Quaternary ammonium compounds in soil: implications for antibiotic resistance development. Reviews in Environmental Science and Bio/Technology, 17(1), 159-185. https://doi.org/10.1007/s11157-017-9457-7

Munita, J. M., & Arias, C. A. (2016). Mechanisms of antibiotic resistance. Microbiology Spectrum, 4(2), 4-2. https://doi.org/10.1128/microbiolspec.VMBF-0016-2015

Murray, S. A., Amachawadi, R. G., Norman, K. N., Lawhon, S. D., Nagaraja, T. G., Drouillard, J. S., & Scott, H. M. (2021). Effects of zinc and menthol-based diets on co-selection of antibiotic resistance among E. coli and Enterococcus spp. in beef cattle. Animals, 11(2), 259. https://doi.org/10.3390/ani11020259

Nhung, N. T., Thuy, C. T., Trung, N. V., Campbell, J., Baker, S., Thwaites, G., Hoa, N. T., & Carrique-Mas, J. (2015). Induction of antimicrobial resistance in Escherichia coli and non-typhoidal Salmonella strains after adaptation to disinfectant commonly used on farms in Vietnam. Antibiotics, 4(4), 480-494. https://doi.org/10.3390/antibiotics4040480

Nicholson, F. A., Chambers, B. J., Williams, J. R., & Unwin, R. J. (1999). Heavy metal contents of livestock feeds and animal manures in England and Wales. Bioresource Technology, 70(1), 23-31. https://doi.org/10.1016/S0960-8524(99)00017-6

Nicholson, F. A., Smith, S. R., Alloway, B. J., Carlton-Smith, C., & Chambers, B. J. (2003). An inventory of heavy metals inputs to agricultural soils in England and Wales. Science of the Total

Environment, 311(1-3), 205-219. https://doi.org/10.1016/S0048-9697(03)00139-6

Nicholson, F. A., Smith, S. R., Alloway, B. J., Carlton?Smith, C., & Chambers, B. J. (2006). Quantifying heavy metal inputs to agricultural soils in England and Wales. Water and Environment Journal, 20(2), 87-95. https://doi.org/10.1111/j.1747-6593.2006.00026.x

O'Neill, J. (2016). Tackling drug-resistant infections globally: Final report and recommendations. (Last accessed: February 2023)

Ortega Morente, E. O., Fernández-Fuentes, M. A., Burgos, M. J. G., Abriouel, H., Pulido, R. P., & Gálvez, A. (2013). Biocide tolerance in bacteria. International Journal of Food Microbiology, 162(1), 13-25. http://dx.doi.org/10.1016/j.ijfoodmicro.2012.12.028

Pal, C., Bengtsson-Palme, J., Kristiansson, E., & Larsson, D. G. (2015). Co-occurrence of resistance genes to antibiotics, biocides and metals reveals novel insights into their co-selection potential. BMC Genomics, 16, 964. https://doi.org/10.1186/s12864-015-2153-5

Pearce, H., Messager, M., & Maillard, J. Y. (1999). Effect of biocides commonly used in the hospital environment on the transfer of antibiotic-resistance genes in Staphylococcus aureus. Journal of Hospital Infection, 43(2), 101–107. https://doi.org/10.1053/jhin.1999.0250

Peng, S., Feng, Y., Wang, Y., Guo, X., Chu, H., & Lin, X. (2017). Prevalence of antibiotic resistance genes in soils after continually applied with different manure for 30 years. Journal of Hazardous Materials, 340, 16-25. https://doi.org/10.1016/j.jhazmat.2017.06.059

Peng, S., Zheng, H., Herrero-Fresno, A., Olsen, J. E., Dalsgaard, A., & Ding, Z. (2021). Co-occurrence of antimicrobial and metal resistance genes in pig feces and agricultural fields fertilized with slurry. Science of the Total Environment, 792, 148259. https://doi.org/10.1016/j.scitotenv.2021.148259

Pérez-Rodríguez, F., & Mercanoglu Taban, B. (2019). A state-of-art review on multi-drug resistant pathogens in foods of animal origin: risk factors and mitigation strategies. Frontiers in Microbiology, 10, 2091. https://doi.org/10.3389/fmicb.2019.02091

Petrovska, L., Mather, A. E., AbuOun, M., Branchu, P., Harris, S. R., Connor, T., Hopkins, K. L., Underwood, A., Lettini, A. A.,

Page, A., Bagnall, M., Wain, J., Parkhill, J., Dougan, G., Davies, R., & Kingsley, R. A. (2016). Microevolution of monophasic Salmonella typhimurium during epidemic, United Kingdom, 2005–2010. Emerging Infectious Diseases, 22(4), 617-624. https://doi.org/10.3201/eid2204.150531

Peyrat, M. B., Soumet, C., Maris, P., & Sanders, P. (2008). Phenotypes and genotypes of Campylobacter strains isolated after cleaning and disinfection in poultry slaughterhouses. Veterinary Microbiology, 128(3-4), 313-326. https://doi.org/10.1016/j.vetmic.2007.10.021

Pontin, K. P., Borges, K. A., Furian, T. Q., Carvalho, D., Wilsmann, D. E., Cardoso, H. R. P., Alves, A. K., Chitolina, G. Z., Salle, C. T. P., de Souza Moraes, H. L., & do Nascimento, V. P. (2021). Antimicrobial activity of copper surfaces against biofilm formation by Salmonella Enteritidis and its potential application in the poultry industry. Food Microbiology, 94, 103645. https://doi.org/10.1016/j.fm.2020.103645

Poole, K. (2017). At the nexus of antibiotics and metals: the impact of Cu and Zn on antibiotic activity and resistance. Trends in Microbiology, 25(10), 820-832. https://doi.org/10.1016/j.tim.2017.04.010

Puangseree, J., Jeamsripong, S., Prathan, R., Pungpian, C., & Chuanchuen, R. (2021). Resistance to widely-used disinfectants and heavy metals and cross resistance to antibiotics in Escherichia coli isolated from pigs, pork and pig carcass. Food Control, 124, 107892. https://doi.org/10.1016/j.foodcont.2021.107892

Ragland, D., Schneider, J. L., Amass, S. F., & Hill, M. A. (2006). Alternatives to the use of antimicrobial feed additives in nursery diets: A pilot study. Journal of Swine Health and Production, 14(2), 82-88. (Last accessed: April 2023)

Randall, L. P., Clouting, C. S., Gradel, K. O., Clifton?Hadley, F. A., Davies, R. D., & Woodward, M. J. (2005). Farm disinfectants select for cyclohexane resistance, a marker of multiple antibiotic resistance, in Escherichia coli. Journal of Applied Microbiology, 98(3), 556-563. https://doi.org/10.1111/j.1365-2672.2004.02488.x

Randall, L. P., Cooles, S. W., Coldham, N. G., Penuela, E. G., Mott, A. C., Woodward, M. J., Piddock, L. J. V., & Webber, M. A. (2007). Commonly used farm disinfectants can select for mutant Salmonella enterica serovar Typhimurium with decreased susceptibility to biocides and antibiotics without compromising virulence. Journal of Antimicrobial Chemotherapy, 60(6), 1273–1280. https://doi.org/10.1093/jac/dkm359

Rensing, C., Moodley, A., Cavaco, L. M., & McDevitt, S. F. (2018). Resistance to metals used in agricultural production. Microbiology Spectrum, 6(2), 6-2. https://doi.org/10.1128/microbiolspec.ARBA-0025-2017

Rhouma, M., Romero-Barrios, P., Gaucher, M. L., & Bhachoo, S. (2021). Antimicrobial resistance associated with the use of antimicrobial processing aids during poultry processing operations: cause for concern? Critical Reviews in Food Science and Nutrition, 61(19), 3279-3296. https://doi.org/10.1080/10408398.2020.1798345

Roedel, A., Vincze, S., Projahn, M., Roesler, U., Robé, C., Hammerl, J. A., Noll, M., Dahouk, S. A., & Dieckmann, R. (2021). Genetic but no phenotypic associations between biocide tolerance and antibiotic resistance in Escherichia coli from German broiler fattening farms. Microorganisms, 9(3), 651. https://doi.org/10.3390/microorganisms9030651

Romero, J. L., Grande Burgos, M. J., Perez-Pulido, R., Galvez, A., & Lucas, R. (2017). Resistance to antibiotics, biocides, preservatives and metals in bacteria isolated from Seafoods: co-selection of strains resistant or tolerant to different classes of compounds. Fronters in Microbiology, 8, 1650. https://doi.org/10.3389/fmicb.2017.01650

Rossi, F., Rizzotti, L., Felis, G. E., & Torriani, S. (2014). Horizontal gene transfer among microorganisms in food: current knowledge and future perspectives. Food Microbiology, 42, 232-243. https://doi.org/10.1016/j.fm.2014.04.004

Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) (2009). Assessment of the antibiotic resistance effects of biocides. (Last accessed: April 2023)

Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) (2010). Research strategy to address the knowledge gaps on the antimicrobial resistance effects of biocides. (Last accessed: April 2023)

Seiler, C., & Berendonk, T. U. (2012). Heavy metal driven co-selection of antibiotic resistance in soil and water bodies impacted by agriculture and aquaculture. Frontiers in Microbiology, 3, 399. https://doi.org/10.3389/fmicb.2012.00399

Shelton, N. W., Jacob, M. E., Tokach, M. D., Nelssen, J. L., Goodband, R. D., Dritz, S. S., de Rouchey, J. M., Amachawadi, R. G., Shi, X., & Nagaraja, T. G. (2009). Effects of copper sulfate, zinc oxide, and neoterramycin on weanling pig growth and antibiotic resistance rate for fecal Escherichia coli. In Kansas State University Swine Day 2009. Report of Progress 1020; Goodband, B., Tokach, M., Dritz, S., de Rouchey, J., Eds.; Kansas State University: Manhattan, KS, USA, 2009; pp. 73–79. (Last accessed January 2023)

Silbergeld, E. K., & Nachman, K. (2008). The environmental and public health risks associated with arsenical use in animal feeds. Annals of the New York Academy of Sciences, 1140(1), 346-357. https://doi.org/10.1196/annals.1454.049

Singer, A. C., Shaw, H., Rhodes, V., & Hart, A. (2016). Review of antimicrobial resistance in the environment and its relevance to environmental regulators. Frontiers in Microbiology, 7, 1728. https://doi.org/10.3389/fmicb.2016.01728

Slifierz, M. J., Friendship, R. M., & Weese, J. S. (2015b). Methicillin-resistant Staphylococcus aureus in commercial swine herds is associated with disinfectant and zinc usage. Applied and Environmental Microbiology, 81(8), 2690–2695. https://doi.org/10.1128/AEM.00036-15

Slifierz, M. J., Friendship, R., & Weese, J. S. (2015a). Zinc oxide therapy increases prevalence and persistence of methicillin-resistant Staphylococcus aureus in pigs: A randomized controlled trial. Zoonoses Public Health, 62, 301–308. https://doi.org/10.1111/zph.12150

Soumet, C., Fourreau, E., Legrandois, P., & Maris, P. (2012). Resistance to phenicol compounds following adaptation to quaternary ammonium compounds in Escherichia coli. Veterinary Microbiology, 158(1-2), 147-152. https://doi.org/10.1016/j.vetmic.2012.01.030

Stevanovi?, Z. D., Bošnjak-Neumüller, J., Paji?-Lijakovi?, I., Raj, J., & Vasiljevi?, M. (2018). Essential oils as feed additives—Future perspectives. Molecules, 23(7), 1717. https://doi.org/10.3390/molecules23071717

Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., & Sutton, D. J. (2012). Heavy metal toxicity and the environment. Molecular, Clinical and Environmental Toxicology: Volume 3: Environmental Toxicology, 133-164. https://doi.org/10.1007/978-3-7643-8340-4_6

Thomas, L., Maillard, J. Y., Lambert, R. J. W., & Russell, A. D. (2000). Development of resistance to chlorhexidine diacetate in Pseudomonas aeruginosa and the effect of a 'residual' concentration. Journal of Hospital Infection, 46(4), 297-303. https://doi.org/10.1053/jhin.2000.0851

Tongyi, Y., Yanpeng, L., Xingang, W., Fen, Y., Jun, L., & Yubin, T. (2020). Co?selection for antibiotic resistance genes is induced in a soil amended with zinc. Soil Use and Management, 36(2), 328-337. https://doi.org/10.1111/sum.12545

Toyofuku, M., Nomura, N., & Eberl, L. (2019). Types and origins of bacterial membrane vesicles. Nature Reviews Microbiology, 17(1), 13-24. https://doi.org/10.1038/s41579-018-0112-2

Tu, Z., Shui, J., Liu, J., Tuo, H., Zhang, H., Lin, C., Feng, J., Feng, Y., Su, W. & Zhang, A. (2023). Exploring the abundance and influencing factors of antimicrobial resistance genes in manure plasmidome from swine farms. Journal of Environmental Sciences, 124, 462-471. https://doi.org/10.1016/j.jes.2021.11.030

Turchi, B., Bertelloni, F., Marzoli, F., Cerri, D., Tola, S., Azara, E., Longheu, C. M., Tassi, R., Schiavo, M., Cilia, G. & Fratini, F. (2020). Coagulase negative staphylococci from ovine milk: Genotypic and phenotypic characterization of susceptibility to antibiotics, disinfectants and biofilm production. Small Ruminant Research, 183, 106030. https://doi.org/10.1016/j.smallrumres.2019.106030

Uddin, M. J., Dawan, J., Jeon, G., Yu, T., He, X., & Ahn, J. (2020). The role of bacterial membrane vesicles in the dissemination of antibiotic resistance and as promising carriers for therapeutic agent delivery. Microorganisms, 8(5), 670. https://doi.org/10.3390/microorganisms8050670

Uruén, C., Chopo-Escuin, G., Tommassen, J., Mainar-Jaime, R. C., & Arenas, J. (2021). Biofilms as promoters of bacterial antibiotic resistance and tolerance. Antibiotics, 10(1), 3. https://doi.org/10.3390/antibiotics10010003

van Alen, S., Kaspar, U., Idelevich, E. A., Köck, R., & Becker, K. (2018). Increase of zinc resistance in German human derived livestock-associated MRSA between 2000 and 2014. Veterinary microbiology, 214, 7-12. https://doi.org/10.1016/j.vetmic.2017.11.032

Van Noten, N., Gorissen, L., & De Smet, S. (2016). Assistance in the Update of the Systematic Literature Review (SLR): "Influence of Copper on Antibiotic Resistance of Gut Microbiota on Pigs (including Piglets)". EFSA supporting publication, 2016:EN-1005. 125 pp. https://doi.org/10.2903/sp.efsa.2016.EN-1005

Vats, P., Kaur, U. J., & Rishi, P. (2022). Heavy metal?induced selection and proliferation of antibiotic resistance: A review. Journal of Applied Microbiology, 132(6), 4058-4076. https://doi.org/10.1111/jam.15492

Verraes, C., Van Boxstael, S., Van Meervenne, E., Van Coillie, E., Butaye, P., Catry, B., De Schaetzen, M. A., Van Huffel, X, Imberechts, H., Dierick, K., Daube, G., Saegerman, C., De Block, J., Dewulf, J., & Herman, L. (2013). Antimicrobial resistance in the food chain: a review. International Journal of Environmental Research and Public Health, 10(7), 2643-2669. https://doi.org/10.3390/ijerph10072643

VKM. (2016). Antimicrobial resistance due to the use of biocides and heavy metals: a literature review. Scientific Opinion on the Panel on Microbial Ecology of the Norwegian Scientific Committee for Food Safety, ISBN: 978-82-8259-253-6, Oslo, Norway. (Last accessed: January 2023)

Von Wintersdorff, C. J., Penders, J., Van Niekerk, J. M., Mills, N. D., Majumder, S., Van Alphen, L. B., Savelkoul, P. H. M., &

Wolffs, P. F. (2016). Dissemination of antimicrobial resistance in microbial ecosystems through horizontal gene transfer. Frontiers in Microbiology, 7, 173. https://doi.org/10.3389/fmicb.2016.00173

Wagner, T., Joshi, B., Janice, J., Askarian, F., Škalko-Basnet, N., Hagestad, O. C., Mekhkif, A., Wai, S. N., Hegstad, K., & Johannessen, M. (2018). Enterococcus faecium produces membrane vesicles containing virulence factors and antimicrobial resistance related proteins. Journal of Proteomics, 187, 28-38. https://doi.org/10.1016/j.jprot.2018.05.017

Wales, A. D., & Davies, R. H. (2015). Co-selection of resistance to antibiotics, biocides and heavy metals, and its relevance to foodborne pathogens. Antibiotics. 4(4):567–604. https://doi.org/10.3390/antibiotics4040567

Wang, H., Dong, Y., Yang, Y., Toor, G. S., & Zhang, X. (2013). Changes in heavy metal contents in animal feeds and manures in an intensive animal production region of China. Journal of Environmental Sciences, 25(12), 2435-2442. https://doi.org/10.1016/S1001-0742(13)60473-8

Wang, J., Wang, L., Zhu, L., Wang, J., & Xing, B. (2022a). Antibiotic resistance in agricultural soils: Source, fate, mechanism and attenuation strategy. Critical Reviews in Environmental Science and Technology, 52(6), 847-889. https://doi.org/10.1080/10643389.2020.1835438

Wang, M., Liu, P., Zhou, Q., Tao, W., Sun, Y., & Zeng, Z. (2018). Estimating the contribution of bacteriophage to the dissemination of antibiotic resistance genes in pig feces. Environmental Pollution, 238, 291-298. https://doi.org/10.1016/j.envpol.2018.03.024

Wang, Q., Awasthi, M. K., Zhang, Z., & Wong, J. W. (2019). Sustainable composting and its environmental implications. In Sustainable Resource Recovery and Zero Waste Approaches (pp. 115-132). Elsevier. https://doi.org/10.1016/B978-0-444-64200-4.00009-8

Wang, Q., Liu, L., Hou, Z., Wang, L., Ma, D., Yang, G., Guo, S., Luo, J., Qi, L., & Luo, Y. (2020). Heavy metal copper accelerates the conjugative transfer of antibiotic resistance genes in freshwater microcosms. Science of the Total Environment, 717, 137055. https://doi.org/10.1016/j.scitotenv.2020.137055

Wang, Z. F., Yun, H., Li, S., Ji, J., Khan, A., Fu, X. L., Zhang, P., & Li, X. K. (2022b). Factors influencing the transfer and abundance of antibiotic resistance genes in livestock environments in China. International Journal of Environmental Science and Technology, 1-12. https://doi.org/10.1007/s13762-022-04031-z

Watts, J. E., Schreier, H. J., Lanska, L., & Hale, M. S. (2017). The rising tide of antimicrobial resistance in aquaculture: sources, sinks and solutions. Marine Drugs, 15(6), 158. https://doi.org/10.3390/md15060158

Webber, M. A., & Piddock, L. J. V. (2003). The importance of efflux pumps in bacterial antibiotic resistance. Journal of Antimicrobial Chemotherapy, 51(1), 9-11. https://doi.org/10.4161/viru.23724

Weber, D. J., Rutala, W. A., & Sickbert-Bennett, E. E. (2019). Use of germicides in health care settings—is there a relationship between germicide use and antimicrobial resistance: A concise review. American Journal of Infection Control, 47, A106-A109. https://doi.org/10.1016/j.ajic.2019.03.023

Wesgate, R., Grasha, P., & Maillard, J. Y. (2016). Use of a predictive protocol to measure the antimicrobial resistance risks associated with biocidal product usage. American Journal of Infection Control, 44(4), 458-464. https://doi.org/10.1016/j.ajic.2015.11.009

Whitehead, R. N., Overton, T. W., Kemp, C. L., & Webber, M. A. (2011). Exposure of Salmonella enterica serovar Typhimurium to high level biocide challenge can select multidrug resistant mutants in a single step. PLoS One, 6(7), e22833. https://doi.org/10.1371/journal.pone.0022833

WHO (World Health Organisation) (2018a). Antimicrobial resistance. (Last accessed: April 2022)

WHO (World Health Organisation) (2018b). Critically Important Antimicrobials for Human Medicine. 6th Revision 2018. (Last accessed: July 2021)

Wieland, N., Boss, J., Lettmann, S., Fritz, B., Schwaiger, K., Bauer, J., & Hölzel, C. S. (2017). Susceptibility to disinfectants in antimicrobial?resistant and?susceptible isolates of Escherichia coli, Enterococcus faecalis and Enterococcus faecium from poultry–ESBL/AmpC?phenotype of E. coli is not associated with resistance to a quaternary ammonium compound, DDAC. Journal of Applied Microbiology, 122(6), 1508-1517. https://doi:10.1111/jam.13440

Williams, O., Clark, I., Gomes, R. L., Perehinec, T., Hobman, J. L., Stekel, D. J., Hyde, R., Dodds, C. & Lester, E. (2019). Removal of copper from cattle footbath wastewater with layered double hydroxide adsorbents as a route to antimicrobial resistance mitigation on dairy farms. Science of the Total Environment, 655, 1139-1149. https://doi.org/10.1016/j.scitotenv.2018.11.330

Woegerbauer, M., Bellanger, X., & Merlin, C. (2020). Cell-Free DNA: An underestimated source of antibiotic resistance gene dissemination at the interface between human activities and downstream environments in the context of wastewater reuse. Frontiers in Microbiology, 11, 671.

https://doi.org/10.3389/fmicb.2020.00671

Wohde, M., Berkner, S., Junker, T., Konradi, S., Schwarz, L., & Düring, R. A. (2016). Occurrence and transformation of veterinary pharmaceuticals and biocides in manure: a literature review. Environmental Sciences Europe, 28, 1-25. https://doi.org/10.1186/s12302-016-0091-8

Wu, N., Zhang, W., Xie, S., Zeng, M., Liu, H., Yang, J., Liu, X. & Yang, F. (2020). Increasing prevalence of antibiotic resistance genes in manured agricultural soils in northern China. Frontiers of Environmental Science & Engineering, 14, 1-12. https://doi.org/10.1007/s11783-019-1180-x

Xiao, X., Bai, L., Wang, S., Liu, L., Qu, X., Zhang, J., Xiao, Y., Tang, B., Li, Y., Yang, H., & Yang, H. (2022). Chlorine tolerance and cross-resistance to antibiotics in poultry-associated Salmonella isolates in China. Frontiers in Microbiology, 12, 833743. https://doi.org/10.3389/fmicb.2021.833743

Xue, H., Wu, Z., Li, L., Li, F., Wang, Y., & Zhao, X. (2015). Coexistence of heavy metal and antibiotic resistance within a novel composite staphylococcal cassette chromosome in a Staphylococcus haemolyticus isolate from bovine mastitis milk. Antimicrobial Agents and Chemotherapy, 59(9), 5788-5792. https://doi.org/10.1128/AAC.04831-14

Xue, J., Wu, J., Hu, Y., Sha, C., Yao, S., Li, P., Lin, K. & Cui, C. (2021). Occurrence of heavy metals, antibiotics, and antibiotic resistance genes in different kinds of land-applied manure in China. Environmental Science and Pollution Research, 28, 40011-40021. https://doi.org/10.1007/s11356-021-13307-9

Yang, H., Wei, S. H., Hobman, J. L., & Dodd, C. E. (2020b). Antibiotic and metal resistance in Escherichia coli isolated from pig slaughterhouses in the United Kingdom. Antibiotics, 9(11), 746. https://doi.org/10.3390/antibiotics9110746

Yang, S., Deng, W., Liu, S., Yu, X., Mustafa, G. R., Chen, S., He, L., Ao, X., Yang, Y., Zhou, K., Li, B., Han, X., Xu, X., & Zou, L. (2020a). Presence of heavy metal resistance genes in Escherichia coli and Salmonella isolates and analysis of resistance gene structure in E. coli E308. Journal of Global Antimicrobial Resistance, 21, 420-426. http://dx.doi.org/10.1016/j.jgar.2020.01.009

Yazdankhah, S., Rudi, K., & Bernhoft, A. (2014). Zinc and copper in animal feed–development of resistance and co-resistance to antimicrobial agents in bacteria of animal origin. Microbial Ecology in Health and Disease, 25(1), 25862. http://dx.doi.org/10.3402/mehd.v25.25862

Yazdankhah, S., Skjerve, E., & Wasteson, Y. (2018). Antimicrobial resistance due to the content of potentially toxic metals in soil and fertilizing products. Microbial Ecology in Health and Disease, 29(1), 1548248. https://doi.org/10.1080/16512235.2018.1548248

Yu, H. R., Li, L. Y., Shan, L. L., Gao, J., Ma, C. Y., & Li, X. (2021). Effect of supplemental dietary zinc on the growth, body composition and anti-oxidant enzymes of coho salmon (Oncorhynchus kisutch) alevins. Aquaculture Reports, 20, 100744. https://doi.org/10.1016/j.aqrep.2021.100744

Yu, Z., Gunn, L., Wall, P., & Fanning, S. (2017). Antimicrobial resistance and its association with tolerance to heavy metals in agriculture production. Food Microbiology, 64, 23–32. https://doi.org/10.1016/j.fm.2016.12.009

Yuan, W., Tian, T., Yang, Q., & Riaz, L. (2020). Transfer potentials of antibiotic resistance genes in Escherichia spp. strains from different sources. Chemosphere, 246, 125736. https://doi.org/10.1016/j.chemosphere.2019.125736

Zalewska, M., B?a?ejewska, A., Czapko, A., & Popowska, M. (2021). Antibiotics and antibiotic resistance genes in animal manure–consequences of its application in agriculture. Frontiers in

Microbiology, 12, 610656. https://doi.org/10.3389/fmicb.2021.610656

Zhang, Y. J., Hu, H. W., Gou, M., Wang, J. T., Chen, D., & He, J. Z. (2017b). Temporal succession of soil antibiotic resistance genes following application of swine, cattle and poultry manures spiked with or without antibiotics. Environmental Pollution, 231, 1621-1632. https://doi.org/10.1016/j.envpol.2017.09.074

Zhang, Y., Gu, A. Z., Cen, T., Li, X., He, M., Li, D., & Chen, J. (2018). Sub-inhibitory concentrations of heavy metals facilitate the horizontal transfer of plasmid-mediated antibiotic resistance genes in water environment. Environmental Pollution, 237, 74-82. https://doi.org/10.1016/j.envpol.2018.01.032

Zhang, Y., Gu, A. Z., He, M., Li, D., & Chen, J. (2017a). Subinhibitory concentrations of disinfectants promote the horizontal transfer of multidrug resistance genes within and across genera. Environmental Science & Technology, 51(1), 570–580. https://doi.org/10.1021/acs.est.6b03132

Zhou, B., Wang, C., Zhao, Q., Wang, Y., Huo, M., Wang, J., & Wang, S. (2016). Prevalence and dissemination of antibiotic resistance genes and coselection of heavy metals in Chinese dairy farms. Journal of Hazardous Materials, 320, 10-17. http://dx.doi.org/10.1016/j.jhazmat.2016.08.007

Zhou, Q., Wang, M., Zhong, X., Liu, P., Xie, X., Wangxiao, J., & Sun, Y. (2019). Dissemination of resistance genes in duck/fish polyculture ponds in Guangdong Province: correlations between Cu and Zn and antibiotic resistance genes. Environmental Science and Pollution Research, 26, 8182-8193. https://doi.org/10.1007/s11356-018-04065-2

Zingali, T., Chapman, T. A., Webster, J., Roy Chowdhury, P., & Djordjevic, S. P. (2020). Genomic characterisation of a multiple drug resistant IncHI2 ST4 plasmid in Escherichia coli ST744 in Australia. Microorganisms, 8(6), 896. https://doi.org/10.3390/microorganisms8060896

Zou, L., Meng, J., McDermott, P. F., Wang, F., Yang, Q., Cao, G., Hoffmann, M., & Zhao, S. (2014). Presence of disinfectant resistance genes in Escherichia coli isolated from retail meats in the USA. Journal of Antimicrobial Chemotherapy, 69(10), 2644–2649. https://doi.org/10.1093/jac/dku197.