ANTIMICROBIAL RESISTANCE AND DAIRY MANURE SYSTEMS

2.A. Antibiotic resistant bacteria - Prevalence in dairy manure

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Antibiotic resistant bacteria (ARB)[1]

ARB are bacteria that have the ability to resist the effects of an antibiotic. Antibiotic resistant bacteria are ancient, and have been found in 30,000-year-old permafrost sediments. Bacteria evolved the ability to resist antibiotics as part of an 'arms race' with competitor bacteria and fungi that naturally produce antibiotics. It is believed, however, that the widespread anthropogenic manufacturing and use of antibiotics in the last century has accelerated this arms race, increasing the prevalence of ARB and antibiotic resistant veterinary and human pathogens.

Acquisition of ARB by cattle[2]

We do not know what the microbial communities in a cow looked like prior to the use of antibiotics on dairy operations. Today we know that ARB are present in a cow. Calves can rapidly develop these populations following initial antibiotic treatments, and may contain them even if they have not received antibiotics. This may be because antimicrobial resistance can be transmitted to calves fed milk from treated cows, by contact with other cattle, animals, shared feed and water, and even via flies, dusts and aerosols.

National Antimicrobial Resistance Monitoring System (NARMS)[3]

The National Antimicrobial Resistance Monitoring System (NARMS) – a collaboration between local and state health departments, universities, the Food and Drug Administration, Centers for Disease Control & Prevention, and United States Department of Agriculture - was established in 1996 to track the prevalence of ARB. The FDA has an interactive online database (NARMS Now) where the prevalence over time of ARB by species (e.g. Salmonella), antibiotics (e.g. Tetracylcine), and source (e.g. dairy cows) can be viewed. Such surveillance efforts are essential to accurately resolve the prevalence of ARB at dairy operations and their potential contribution to the proliferation of antibiotic resistance.

Prevalence of ARB[2]

The average prevalence of ARB in US dairy manure, based on NARMS and other scientific data, is summarized in Table 1. Generally, less than 15% of tested bacterial isolates from US dairy manure samples are ARB, though for some bacterial species and antibiotics, higher prevalences have been reported. Resistance to tetracycline appears the most prevalent, and can be found in over 75% of some isolates.

The impact of antibiotic usage on ARB prevalence is not clear. At the cow-level, ARB are sometime more prevalent following an antibiotic treatment, but the shedding of ARB is typically short lived. As a result, correlations are usually only found between antibiotics and ARB immediately after treatment. At the farm-level, ARB are sometimes more prevalent on conventional dairy operations, but ARB can also be found on organic dairy operations. It is currently unresolved if the ARB at these organic dairies are part of a natural background level, or if they developed before the farm converted to organic production, and have persisted.

Though some may persist, studies conducted on dairy cow isolates collected over the last 20-years have not found an increase in prevalence of antibiotic resistant bovine pathogens. Generally there has been little change in the prevalence of most dairy associated ARB, including antibiotic resistant *E. coli*. A decline in the prevalence of antibiotic resistant *Staphylococcus* on dairy operations has also been observed. What drives the prevalence of ARB on dairy operations is currently unknown.

TABLE 1. AVERAGE PREVALENCE (% OF TESTED ISOLATES) OF ARB IN US DAIRY MANURE SAMPLES BY BACTERIAL SPECIES AND ANTIBIOTIC. BASED ON REVIEW BY OLIVER ET AL., 2018[2]. NO RESISTANCE IS INDICATED BY A ZERO, BLACK INDICATED DATA IS NOT AVAILABLE.

Antibiotic class	Antibiotic compound	*E. coli* (%)	*Salmonella* spp. (%)	*Campylobacter* spp. (%)	*Enterococcus* spp. (%)	*Staphylococcus* spp. (%)
Aminocoumarin	Penicillin/Novobiocin					1.3
Aminoglycoside	Amikacin	0.0	0.0			
	Apramycin	0.9				
	Clindamycin			1.0 - 9.1		
	Gentamicin	0.0 - 2.6	0.0 - 4.4	0.0 - 1.8	0.0 - 1.4	
	Kanamycin	0.0 - 14	0.7 - 31	30 - 32	0.0 - 2.9	
	Neomycin		26			
	Spectinomycin		14			
	Streptomycin	6.3 - 15	9.0 - 44	0.6 - 1.6	0.0 - 5.6	
Cephalosporin	Cefoxitin	0.9 - 1.5	3.7 - 40			
	Ceftiofur	0.6 - 6.5[3]	4.4 - 34			
	Ceftriaxone	0.0 - 2.8	0.0 - 39	1.4 - 2.3		
	Cephalothin	4.1	4.8 - 8.8			
Chloramphenicol	Chloramphenicol	2.3 - 4.0	4.4 - 37	0.0 - 1.1	0.0 - 1.3	
Fluoroquinolone	Ciprofloxacin	0.0 - 0.9	0.0 - 0.3	0.9 - 47	0.0 - 50	
	Enrofloxacin		0.6			
	Florfenicol		37	0.0 - 0.3		
	Nalidixic acid	0.0 - 1.8	0.0 - 0.4	1.3 - 47		
Glycylcycline	Tigecycline				0.0	
Glycopeptide	Vancomycin				0.0	
Ketolide	Telithromycin			0.3 - 7.4		
Lincosamide	Lincomycin				0.0 - 99	
Lipopeptide	Daptomycin				1.4 - 1.9	
Macrolide	Azithromycin	0.0 - 0.6	0.0 - 0.5	0.0 - 9.1		
	Erythromycin			0.3 - 9.1	0.0 - 8.7	0.8
	Tylosin				1.3 - 10	
Nitrofuran	Nitrofurantoin				0.0	
Oxazolidinone	Linezolid				0.0	
Penicillin	Amoxicillin/Clavulanic acid	1.3 - 1.8	4.8 - 40	0.0 - 0.1		
	Ampicillin	1.8 - 13	4.4 - 42			0.4
	Penicillin			7.1 - 8.6	0.0	1.3
	Penicillin/Novobiocin					1.3
Streptogramins	Quinupristin/Dalfopristin				1.3 - 8.8	
Sulfonamide	Sulfamethoxazole	14	3.7 - 11	37 - 39		
	Sulfamethoxazole/Sulfisoxazole	5.5 - 11	9.0 - 11			
	Sulfadimethoxine		72			19
	Sulfisoxazole		44			
	Trimethoprim/Sulfamethoxazole	0.0 - 5.0	0.0 - 6.6			
Tetracycline	Chlortracycline		41			
	Tetracycline	6.7 - 26	12 - 44	49 - 76	7.1 - 45	2.9
	Oxytetracyclines		42			
Resistant to more than 5 antibiotics		0.5-8.7	8.6			0.4 - 0.8

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References

[1] D'Costa et al. 2011. *Nature*. [2] Oliver et al. 2018. *Journal of Dairy Science*. [3] NARMS. 2018. https://www.fda.gov/animalveterinary/safetyhealth/antimicrobialresistance/nationalantimicrobialresistancemonitoringsystem/

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