AHEAD IN
ANIMAL HEALTH

Monitoring of antimicrobial susceptibility of *Streptococcus suis* in the Netherlands, 2013–2018

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Aim

Evaluation of the *in-vitro* antimicrobial susceptibility of *Streptococcus suis* isolates from diseased pigs in the Netherlands, 2013-2018.

Materials & Methods

Antimicrobial susceptibility testing results (broth micro-dilution) were obtained from the Laboratory Information Management System of GD Animal Health (GD AH). The study period was April 2013 up to and including December 2018.
S. suis isolates were originally cultured from either diseased pigs submitted to GD AH for pathological examination or from samples submitted to GD AH for bacteriological culture and susceptibility testing.
Minimal inhibitory concentrations (MICs) were interpreted as susceptible (S), intermediate (I) and resistant (R) using CLSI veterinary-specific breakpoints (when available). Of those antimicrobials with known breakpoints for *S. suis*, data were analysed using multivariable logistic regression models in Stata (R as I+R).

Conclusions

S. suis isolates from diseased pigs showed good susceptibility to ampicillin, ceftiofur, enrofloxacin, FFL, PEN, and T/S. Susceptibility to CLI was moderate, and to TET poor.
Although isolates still show good susceptibility for FFL and T/S, levels of resistance to these antimicrobials increased over the years 2013-2018. Likewise, there was an increase of resistance to TET.
For some antimicrobials, an effect of season, farm of origin, and/or age category on percentages of resistant isolates was found.

Results

MIC results for 3,269 *S. suis* isolates from 1,123 unique, commercial pig farms were available for further analysis (1-25 isolates per farm, median n=2).
3,169 isolates originated from post-mortem examinations and 100 isolates were cultured from submitted samples.
For 2,313 (out of 3,269) *S. suis* isolates the age category (suckling, weaned, grow/finish) was known.

Table 1. MIC distribution (%) for *Streptococcus suis* isolates (n=3,269) originating from pigs submitted for post-mortem examination at GD AH and from samples submitted to the laboratory of GD AH, 2013-2018

Antimicrobial	MIC values (µg/mL)																MIC_{50} (µg/mL)	MIC_{90} (µg/mL)	Interpretation		
	0.03125	0.0625	0.125	0.25	0.5	1	2	4	8	16	32	64	128	256	512	1024			S (%)	I (%)	R (%)
Amoxicillin/Clavulanic acid[a]				98.8	0.7	0.3	0.1	0.1	0.0	0.0	0.0	0.0					≤0.25	≤0.25	-	-	-
Ampicillin		**97.2**	**1.2**	**0.9**	**0.2**	**0.2**	**0.2**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**					**≤0.0625**	**≤0.0625**	**99.5**	**0.2**	**0.3**
Cefepime					98.9	0.6	0.4	0.0	0.0	0.0	0.2						≤0.5	≤0.5	-	-	-
Ceftiofur				**95.6**	**2.6**	**0.5**	**0.7**	**0.2**	**0.2**	**0.2**							**≤0.25**	**≤0.25**	**99.4**	**0.2**	**0.4**
Clindamycin				52.1	0.7	0.6	0.6	1.8	44.2								≤0.25	>4	52.1	0.7	47.2
Enrofloxacin				84.9	14.1	0.5	0.1	0.1	0.2								≤0.25	0.5	99.1	0.5	0.4
Erythromycin			52.8	0.8	0.3	0.3	0.9	0.9	1.9	42.1							≤0.125	>8	-	-	-
Florfenicol							98.0	1.6	0.2	0.1	0.2						≤2	≤2	98.0	1.6	0.5
Neomycin								10.8	27.0	41.9	20.3						16	>16	R_{int}	R_{int}	R_{int}
Oxacillin				91.0	7.8	0.7	0.2	0.1	0.1	0.1							≤0.25	≤0.25	-	-	-
Penicillin G		**93.0**	**3.2**	**2.1**	**1.1**	**0.3**	**0.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**					**≤0.0625**	**≤0.0625**	**98.3**	**1.1**	**0.6**
Sulfamethoxazole										8.9	0.4	0.9	0.8	0.5	1.7	86.7	>512	>512	-	-	-
Tetracycline				**2.4**	**5.9**	**11.3**	**4.6**	**1.8**	**4.5**	**17.7**	**51.8**						**>16**	**>16**	**8.3**	**11.3**	**80.4**
Tilmicosin								9.4	19.4	23.3	2.8	45.0					16	>32	-	-	-
Trimethoprim/Sulfamethoxazole[b]	**0.0**	**11.2**	**18.0**	**8.3**	**49.3**	**2.9**	**3.0**	**1.5**	**5.9**								**0.5**	**2**	**86.8**	**5.9**	**7.4**

The green, red, and blue areas indicate the dilution range tested for each antimicrobial agent. Values (in red) above this range indicate MIC values higher than the highest concentration within the range. Values corresponding to the lowest concentration tested indicate MIC values lower than or equal to the lowest concentration within the range. When available, susceptible and resistance breakpoints are indicated in vertical green (susceptible) and white (resistant) lines (solid line = animal species-specific; dotted line = human-derived veterinary breakpoints (CLSI).
In bold the antibiotics mentioned in the Dutch treatment Formulary for Pigs for *S. suis* infections are shown.
[a] Concentration for amoxicillin given, tested with clavulanic acid in a concentration ratio 2:1. [b] Concentration for trimethoprim given, tested with sulfamethoxazole in a concentration ratio 1:19.

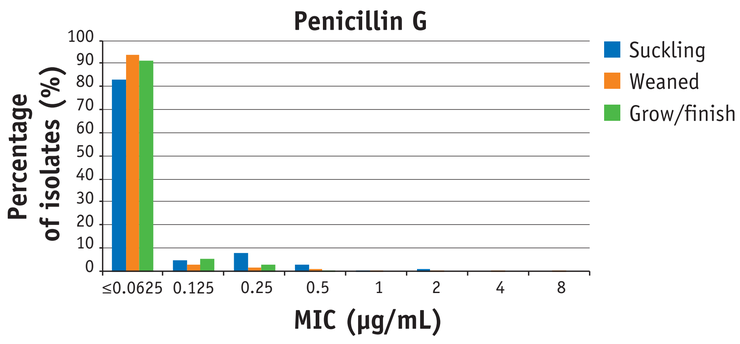

Figure 1. Percentage of *Streptococcus suis* isolates per age category per MIC value of Penicillin G, 2013-2018

Since almost all isolates were susceptible for ampicillin, ceftiofur, and enrofloxacin, no multivariable logistic regression analysis was done with data obtained for these three antimicrobials.

Year

Of the five remaining antimicrobials, MIC values of florfenicol (FFL), tetracycline (TET), and trimethoprim/sulfamethoxazole (T/S) increased through the study period resulting in higher levels of resistance. Every increase in year resulted in higher odds for isolates to be resistant (with ODDs ratios of 2.7, 1.4, and 1.3, respectively).

Season

For FFL, *S. suis* isolated in summer (Jul-Sep) had higher odds to be resistant compared to those isolated in autumn (Oct-Dec) and winter (Jan-Mar). Also for TET, *S. suis* isolated in summer had higher odds to be resistant compared to those isolated in autumn. And for T/S, *S. suis* isolated in winter had higher odds to be resistant compared to those isolated in spring (Apr-Jun).

Farm

For clindamycin (CLI), TET, and T/S, percentages of resistance were significantly affected by farm of origin, with resistance of isolates from the same farm more alike compared to resistance of isolates from different farms.

Age

While for penicillin G (PEN), isolates from suckling piglets had higher odds to be resistant than isolates from weaned piglets and grow/finish pigs, see Figure 1, for TET, isolates from suckling piglets had lower odds to be resistant than isolates from weaned piglets and grow/finish pigs. Also for TET, isolates from weaned piglets had higher odds to be resistant than isolates from grow/finish pigs.

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