7.7 *Staphylococcus aureus*

Staphylococcus aureus belong to the most important micro-organisms in clinical microbiology. Besides bloodstream infections, *S. aureus* frequently causes soft-tissue infections, osteomyelitis, joint infections, and, more rarely, endocarditis and pneumonia. Methicillin-resistant *S. aureus* (MRSA) remains one of the most important causes of antimicrobial-resistant infections worldwide. While initially these infections were mainly hospital acquired, they have now largely spread into the community over the last years.

There are different methods to detect MRSA, and the methods used for screening have changed over time. *Staphylococcus aureus* methicillin/oxacillin resistance can be detected either phenotypically by MIC determination, disk diffusion tests or latex agglutination to detect PBP2a, or genotypically using *mecA* /*mecC* gene detection. Due to poor correlation with the presence of *mecA* (the gold standard for defining methicillin resistance), oxacillin disk testing to detect *S. aureus* methicillin/oxacillin resistance is discouraged by EUCAST and CLSI guidelines. In contrast, cefoxitin susceptibility is a very sensitive and specific marker of *mecA/mecC* -mediated methicillin resistance and is the drug of choice for disk diffusion testing. *S. aureus* with cefoxitin MIC values > 4 mg/L are methicillin resistant, mostly due to the presence of the *mecA* gene.

In the ANRESIS database, MRSA is defined as non-susceptibility to at least one of the following: methicillin, oxacillin, flucloxacillin or cefoxitin. Confirmation tests, such as PBP2a agglutination or direct detection of the *mecA* gene, are typically not forwarded to ANRESIS. MRSA are resistant to all beta-lactam, including combinations with beta-lactam inhibitors (e. g. amoxicillin-clavulanic acid). In 2019, the MRSA rate in Switzerland was 3.4%, with slightly higher rates in southern and western Switzerland (Table 7. k). This rate is far below the European average of 16.4%, but above MRSA rates in Northern countries such as Norway (0.9%), the Netherlands (1.2%), Denmark (1.7%), Sweden (1.9%) and Finland (2.0%) in 2018 [2]. Co-resistance in MRSA is frequent and is depicted in Figure 7. n.

Staphylococcus aureus also remains an important pathogen in the ambulatory setting, where it is the major causative agent of wound infections and abscesses. A comparison of the resistance rates of invasive samples with outpatient samples from wound and abscesses is shown in Figure 7. m. As already shown by Olearo *et al.* [9], MRSA rates and, similarly, non-susceptibility rates to most other antibiotics as well, are nowadays higher in the ambulatory skin infection setting (7.2%) than in bacteremia (3.4%) (Figure 7. m). While MRSA rates in hospitals have been decreasing since several years, community MRSA (cMRSA) infections are increasing [9]. In addition, they often harbor the Panton-Valentine leukocidin (PVL) toxin, leading to the formation of abscesses. Importantly, wound infections and even skin abscesses usually can be treated by a surgical procedure only, and do not need antibiotic therapy.

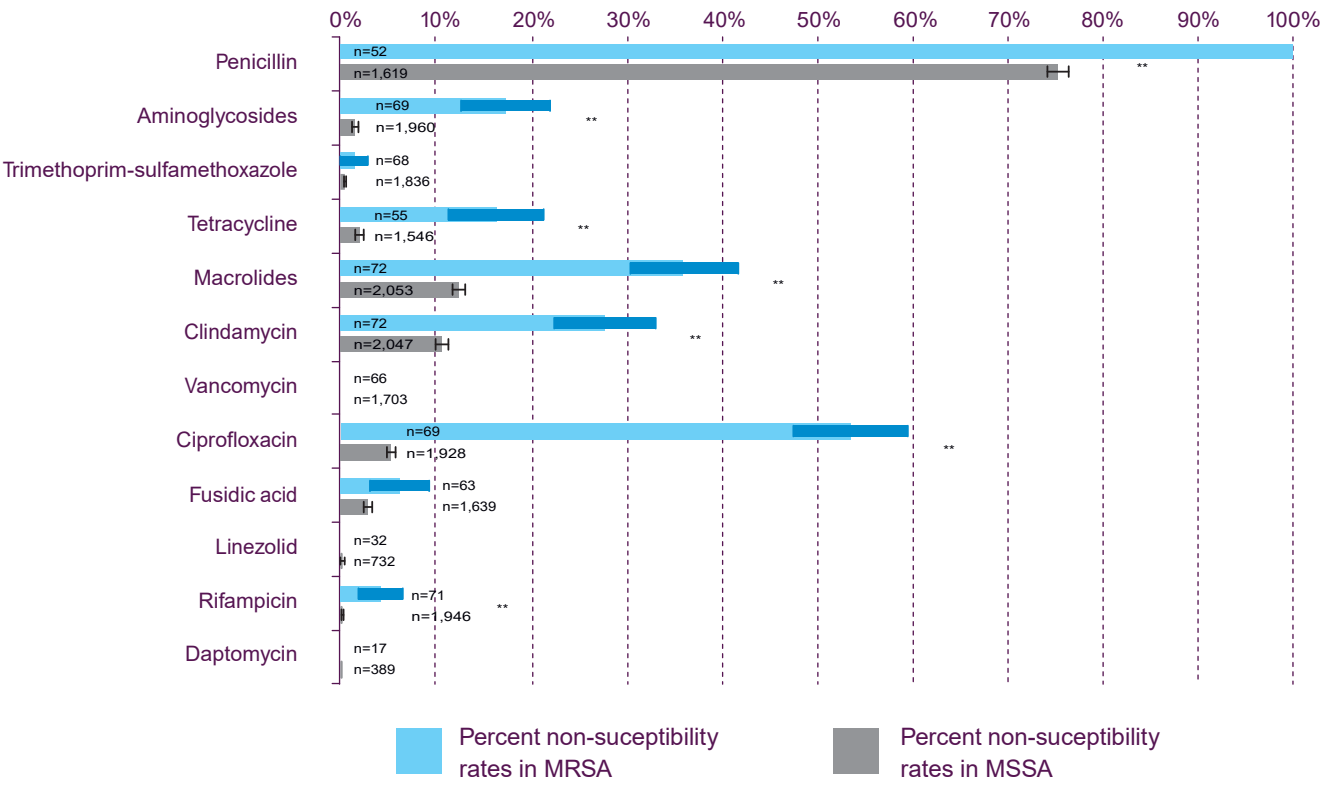
Development of resistances during the last ten years is shown in Figure 7. o. Over the past ten years, we have observed a significant decrease in invasive MRSA rates in Switzerland, from 8.5% in 2010 to 3.4% in 2019. Decreasing trends from 2016 to 2018 were also reported in almost one third of all European countries, leading to an overall decrease in the population-weighted mean of EU/EEA states from 19.0% to 16.4% during this time period [2]. The decrease in invasive MRSA rates was more pronounced in the western part of Switzerland (data not shown). The decrease in the MRSA rate runs parallel to significant decreases in the non-susceptibility rates against ciprofloxacin and aminoglycosides in *Staphylococcus aureus* isolates (Figure 7. i). After an initial decrease of non-susceptibility rates against macrolides and clindamycin, these rates increased again over the past four years back to the levels observed in 2010.

Table 7. k: Susceptibility rates of invasive *Staphylococcus aureus* isolates in humans in 2019.

Staphylococcus aureus											2019
	West		North–East		South		Total			Trend	
Antimicrobial	n	%	n	%	n	%	n	%	95% CI	4y	10y
Penicillin	307	68.1%	1,304	77.7%	116	80.2%	1,727	76.1%	75.1–77.1	–	–
MRSA	432	5.1%	1,618	2.7%	77	7.8%	2,127	3.4%	3.0–3.8	–	↓
Aminoglycosides	444	2.0%	1,523	2.1%	116	1.7%	2,083	2.1%	1.8–2.4	–	↓
Trimethoprim-sulfamethoxazole	447	0.9%	1,398	0.6%	116	0.9%	1,961	0.7%	0.5–0.9	–	–
Tetracycline	297	1.7%	1,241	2.8%	116	0.9%	1,654	2.5%	2.1–2.9	–	–
Macrolides	446	19.3%	1,618	11.6%	116	16.4%	2,180	13.4%	12.7–14.1	–	–
Clindamycin	446	18.2%	1,613	9.5%	116	11.2%	2,175	11.4%	10.7–12.1	↑	–
Vancomycin	405	0.0%	1,305	0.0%	116	0.0%	1,826	0.0%	0.0–0.0	–	–
Ciprofloxacin	371	7.3%	1,566	6.6%	116	10.3%	2,053	6.9%	6.3–7.5	↓	↓
Fusidic acid	362	5.2%	1,275	2.4%	116	1.7%	1,753	3.0%	2.6–3.4	–	–
Linezolid	261	0.4%	504	0.2%	0	0.0%	765	0.3%	0.1–0.5	–	–
Rifampicin	443	0.7%	1,513	0.2%	116	0.0%	2,072	0.3%	0.2–0.4	–	–
Daptomycin	132	0.0%	274	0.4%	4	0.0%	410	0.2%	0.0–0.4	–	–

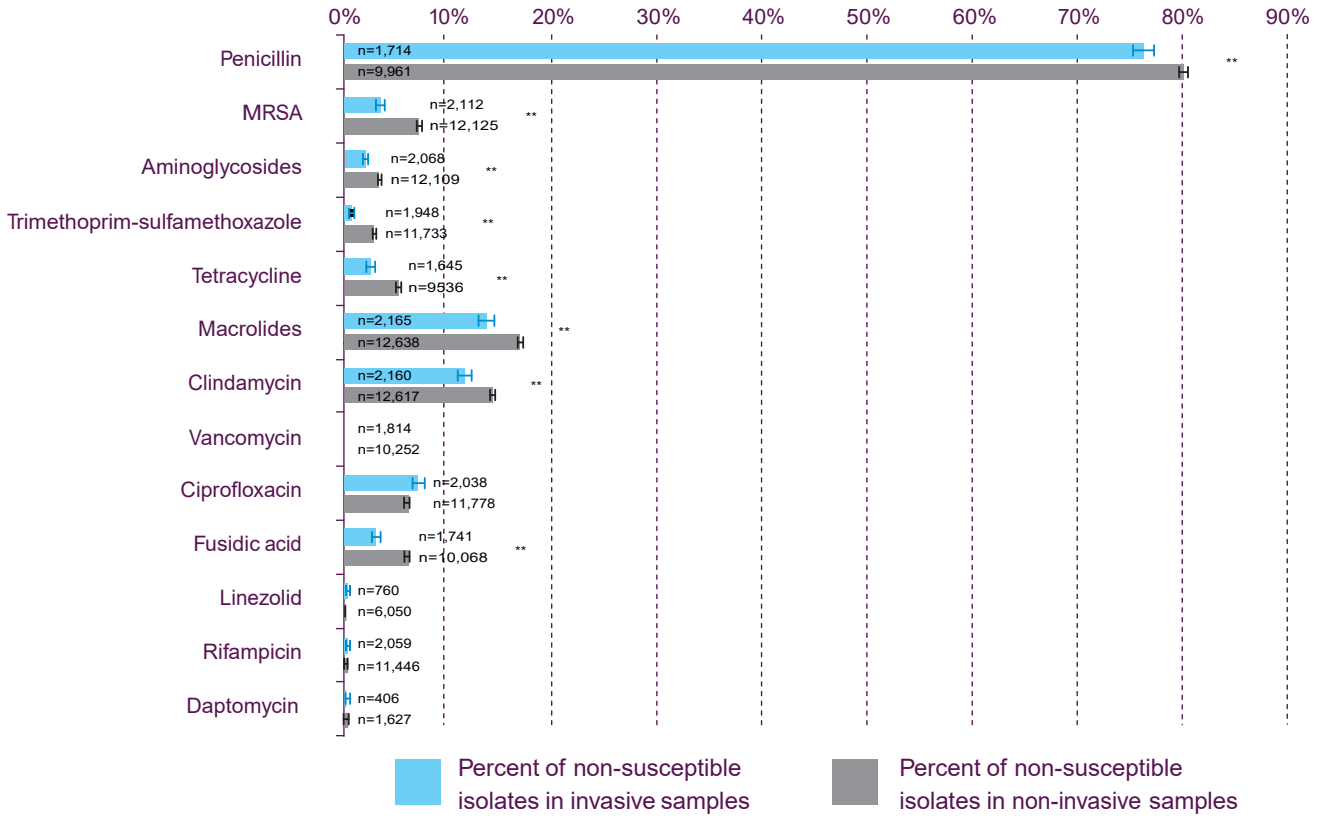
West (GE, NE, VD, JU, FR), South (TI), North–East (other cantons) according to linguistic regions.
95% confidence intervals (CI) were calculated by the Wilson score method, calculations of trends were performed by logistic regression.
Trends were modelled with logistic regressions. Arrows represent a significant effect ($p < 0.05$) of the year on the correspondent outcome (increase, decrease).

Figure 7. n: Non-susceptibility rates of invasive MRSA (methicillin-resistant *Staphylococcus aureus*) and MSSA (methicillin-susceptible *Staphylococcus aureus*) isolates in humans in 2019.



n = number of isolates tested, with error bars indicating 95% confidence intervals. Fisher Exact Tests were performed to assess for independence:
** = p-value <0.01.

Figure 7. m: Comparison of non-susceptibility rates of *Staphylococcus aureus* in invasive versus outpatient wound/abscess samples in humans in 2019.



n = number of isolates tested, with error bars indicating 95% confidence intervals. Fisher Exact Tests were performed to assess for independence:
** = p-value <0.01.

Figure 7. o: Non-susceptibility rates of invasive *Staphylococcus aureus* isolates in humans between 2010 and 2019.