7.7 *Staphylococcus aureus*

Staphylococcus aureus belong to the most important microorganisms in clinical microbiology. Besides bloodstream infections, *S. aureus* frequently causes soft-tissue infections, osteomyelitis, joint infections, and, more rarely, endocarditis and pneumonia. As observed in many European countries [13], *S. aureus* bacteremias are also increasing in Switzerland. In a recent study by ANRESIS, an increase from 1,240 cases in 2011 to 2,260 cases in 2021 (+83%), mainly due to methicillin-susceptible *S. aureus* (MSSA), was reported [14]. However, methicillin-resistant *S. aureus* (MRSA) remains one of the most important causes of antimicrobial-resistant infections worldwide. While initially these infections were typically hospital-acquired, they have now largely spread into the community.

There are different methods to detect MRSA, and the screening methods 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 resistance to at least one of the following antibiotics: methicillin, oxacillin, flucloxacillin or cefoxitin. The results of confirmatory tests, such as the PBP2a agglutination test or the direct detection of the *mecA* gene, are typically not forwarded to ANRESIS. MRSA are resistant to all beta-lactam antibiotics, including combinations with beta-lactam inhibitors (e. g., amoxicillin-clavulanic acid). In 2021, the MRSA rate in Switzerland was 4.7%, with higher rates in southern Switzerland (18.8%), followed by western Switzerland (5.4%, Table 7. k). On average, Switzerland belongs to the 9 out of 40 (23%) European countries with MRSA rates below 5% [2]. Coresistance in MRSA is frequent and significantly higher than in MSSA for almost all antibiotics (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 wounds and abscesses is shown in Figure 7. m. As already shown by Olearo et *al.* [15], MRSA rates, and similarly resistance rates to most other antibiotics, are nowadays significantly higher in the ambulatory skin infec-

Table 7. k: Resistance rates of invasive *Staphylococcus aureus* isolates in humans in 2021.

Staphylococcus aureus											**2021**
	West		**North–East**		**South**		**Total**			**Trend**	
Antimicrobial	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**95% CI**	**4y**	**10y**
Penicillin	210	93.8	1,230	82.8	146	69.2	1586	83	82.1–83.9	↑	↑
MRSA	446	5.4	1,904	4.1	64	18.8	2,414	4.7	4.3–5.1	–	↓
Aminoglycosides	467	5.8	1,746	2.6	156	1.3	2,369	3.1	2.7–3.5	–	↓
Trimethoprim-sulfamethoxazole	481	0.6	1,746	0.7	156	0.6	2,383	0.7	0.5–0.9	–	–
Tetracycline	361	4.7	1,463	4.5	156	2.6	1,980	4.4	3.9–4.9	–	–
Macrolides	479	21.3	1,904	11.4	156	15.4	2,539	13.5	12.8–14.2	–	↑
Clindamycin	480	17.9	1,904	9.7	156	12.8	2,540	11.5	10.9–12.1	↑	↑
Vancomycin	409	0.2	1,530	0	152	0	2,091	0	0.0–0.0	–	–
Ciprofloxacin	463	8.9	1,674	4.1	156	12.8	2,293	5.6	5.1– 6.1	–	↓
Fusidic acid	458	3.3	1,399	3.4	146	7.5	2,003	3.6	3.2–4.0	–	–
Linezolid	279	0	607	0	3	0	889	0	0.0–0.0	–	–
Rifampicin	476	0.8	1,759	0.3	146	0.7	2,381	0.5	0.4–0.6	–	–
Daptomycin	168	0.6	557	0.5	133	2.3	858	0.8	0.5–1.1	–	–

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 modeled with logistic regressions. Arrows represent a significant effect ($p < 0.05$) of the year on the corresponding outcome (increase, decrease).

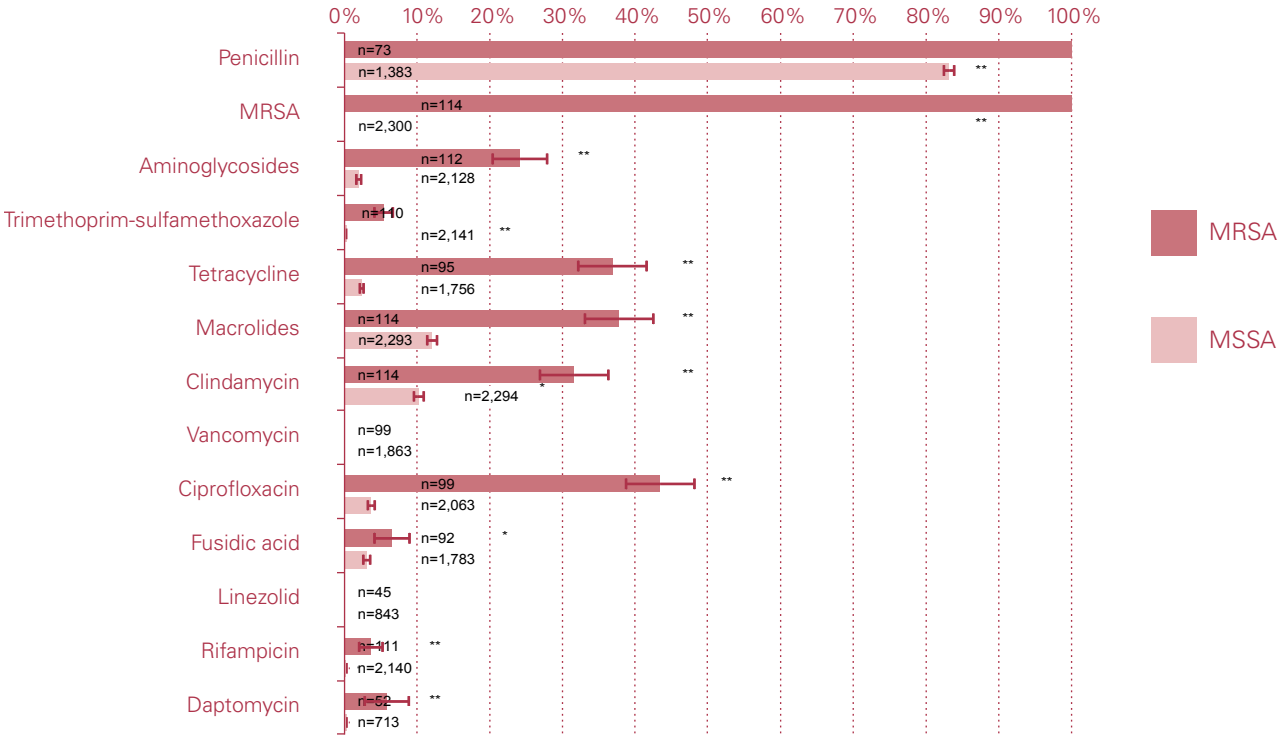
tion setting (11.6%) than in bacteremia (4.7%, Figure 7. m). While MRSA rates in hospitals have been decreasing for several years, community MRSA (cMRSA) infections are increasing [15]. In addition, they often harbor the Panton-Valentine-Leukocidin (PVL) toxin, leading to the formation of abscesses. Importantly, wound infections and even skin abscesses can usually be treated by a surgical procedure alone, and do not need antibiotic therapy.

The development of resistances during the last ten years is shown in Figure 7. o. Over the past ten years (2012–2021), a significant decrease in invasive MRSA rates, from 6.7% to 4.7%, was observed in Switzerland. A decrease in the MRSA percentage between 2016 and 2020, from 19.3% to 16.7%, was described in the population-weighted mean of EU/EEA states as well [2]. The decrease in the MRSA rate runs parallel to significant decreases in the resistance rates against aminoglycosides and ciprofloxacin in *S. aureus* isolates (Figure 7. i). In contrast, resistance rates in invasive *S. aureus* significantly increased for macrolides and clindamycin during the last ten years, from 11.2% to 13.5% and 8.3% to 11.5%, respectively.

Figure 7. m: Comparison of resistance rates in invasive versus outpatient wound/abscess samples in *Staphylococcus aureus* in humans in 2021.

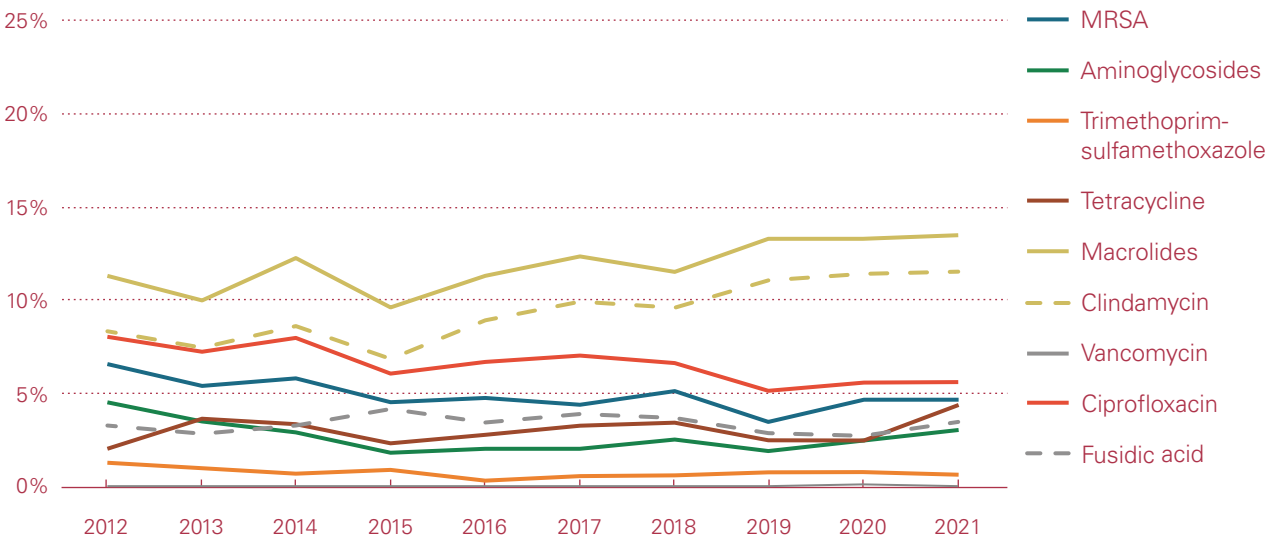
n = number of isolates tested, with error bars indicating 95% confidence intervals. Fisher Exact Tests were performed to assess for independence:
** = p-value <0.01.

Figure 7. n: Resistance rates of invasive MRSA (methicillin-resistant *Staphylococcus aureus*) and MSSA (methicillin-susceptible *Staphylococcus aureus*) isolates in humans 2021.



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: Resistance rates of invasive *Staphylococcus aureus* isolates in humans between 2012 and 2021.



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