
Antiseptic Stewardship

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Antiseptic Stewardship

Biocide Resistance and Clinical
Implications

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Foreword

Biocides (disinfectants, antiseptics, preservatives) usage has increased worldwide notably for applications that do not necessarily require the application of biocides, particularly in the home environment. The amount of biocides used in Europe is difficult to quantify as the number of products containing a biocide and biocide applications have increased dramatically in the last 10 years. It is thus logical to assume that microbial exposure to biocides has also increased. Parallel, but not separate, from the increase in biocidal products commercially available is the rise in antimicrobial resistance (AMR) in bacteria, which results primarily from the overuse and misuse of chemotherapeutic antibiotics for human and veterinary medicine, but also for industrial processes such as fermentation. Recent calculations from Lord O'Neil's AMR report to the British government predict human deaths caused by untreatable AMR to reach 10 million worldwide by 2050, well above other diseases including cancer. Biocidal products have a role to play in reducing AMR notably on hard and porous surfaces, with disinfection and antiseptics, and in products through preservation. The increase in biocidal products is most likely due to a better understanding by the public of hygiene concepts and AMR, and the absolute need to control infection, creating opportunities for the industry to meet the need for products that can inhibit or eliminate the risk of infection or spoilage. Although biocidal products play an essential part in controlling micro-organisms on surfaces and in products, the overuse of biocides and biocidal products has raised concerns among regulators, about environmental toxicity following product applications, and on risks associated with emerging bacterial resistance to specific biocidal agents, and cross-resistance to unrelated substances including chemotherapeutic antibiotics. In Europe, the Biocidal Products Regulation now mentioned the need for manufacturers to measure the impact of biocidal products on emerging resistance and cross-resistance, while the US Food and Drug Administration has recently published a rule to restrict the use of a number of cationic and phenolic biocides in certain products, based on potential toxicity and bacterial resistance issues.

Hence, if the use of biocides and biocidal products is necessary and beneficial on the one hand, overuse and misuse of biocides may be detrimental on the other hand. This book looks at the main biocides used in common formulations developed for healthcare applications. It provides useful information on biocide activity against

bacteria and fungi, and evidence of emerging resistance and cross-resistance following biocide exposure. It also dedicates a number of chapters promoting appropriate biocidal product usage and good stewardship of biocidal products in healthcare settings. The subjects presented in this book are topical and of great interests. Overall, the information provided in this book provides a better understanding of the efficacy and limitations of commonly used biocides and their applications.

Cardiff, UK
June 2018

Prof. Jean-Yves Maillard
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Preface

A chemical that constantly stresses bacteria to adapt, and behaviour that promotes antibiotic resistance needs to be stopped immediately when the benefits are null.

Patrick J. McNamara and Stuart B. Levy (2016)

The indicated use of antiseptics and disinfectants is regarded as a major contribution to prevent the transmission of multidrug- or pan-resistant pathogens. Some antiseptic products, however, contain additional non-volatile active ingredients with a doubtful or sometimes even without a contribution to the overall antimicrobial efficacy. But these agents can at the same time cause adaptation and resistance, mainly among Gram-negative bacterial species. The resistance may even cover other biocidal agents or selected antibiotics. Chlorhexidine digluconate is such a biocidal agent used in different types of products such as alcohol-based hand rubs, antimicrobial soaps, alcohol-based skin antiseptics and antiseptic mouth rinses. In some of the applications, there is good evidence that it contributes to patient safety, e.g. when used in combination with alcohol as a skin antiseptic for the insertion of a central venous catheter or for puncture site care. Its effect in alcohol-based hand rubs, however, is at least doubtful.

After my publication in the *Journal of Hospital Infection* in 2016 on acquired resistance to chlorhexidine and the proposal to establish an antiseptic stewardship initiative, I have received some very encouraging emails from clinical colleagues who were grateful for the review and who supported the principal idea of an antiseptic stewardship based on their own clinical experience. This type of feedback was motivation enough to look at the entire topic in a broader perspective.

Although the evaluation of biocidal agents was done with a lot of care for completeness and experimental details, I may still have missed some studies. But the overall picture is probably quite complete and allows learning which of the biocidal agents has a higher risk for promoting resistance in which types of pathogens. Healthcare workers are invited to critically look at the product labels in the section “composition” and to find out which of the active agents is in the product even if not declared as an active agent. Regulatory authorities are invited to ask the manufacturers about the evidence-based antimicrobial effects of specific substances which may even result in non-approval of specific products if the risks

for selection pressure by a substance outweigh any possible benefits. And manufacturers are invited to take all the findings into account when formulating antiseptic products. At the end, I hope that the book contributes to reducing unnecessary selection pressure by the different types of antiseptic agents.

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About this Book

For this book, typical antiseptic substances have been selected which are used in various fields of applications (e.g. human medicine, veterinary medicine, food production and handling) and are used in at least two types of antiseptic products (e.g. hand disinfectants, surface disinfectants, skin antiseptics) by at least two manufacturers. Another prerequisite was to have published evidence available for each antiseptic agent allowing a best possible comprehensive review of its antimicrobial efficacy and resistance. One aspect is very important in this context. The summary on each biocidal agent aims to provide a neutral and complete picture but does not intend to favour or disadvantage specific biocidal agents. It does also not intend to favour or disadvantage specific manufacturers or companies.

In the first part of each chapter, the chemical is characterized followed by its typical applications including the regulatory frame in the European Union and the USA. A summary of the activity of each antiseptic agent against bacteria, fungi and mycobacteria is the next part. It includes an overview on MIC values to determine a microbiostatic activity and data from suspension tests to determine a microbiocidal activity obtained with culture collection strains and all other types of clinical and environmental isolates. It also includes a description of the efficacy against the micro-organisms in biofilms. Viruses were not included because adaptation and resistance were regarded as defence mechanisms of living cells. Bacterial spores were also not included because they are considered the most resistant form of a micro-organism anyway so that an adaptation or an acquired resistance is not expectable and is unlikely to change the use of antiseptics.

It is followed by all data on any type of adaptive response by micro-organisms to low-level exposure to the biocidal agent. This may be a change of susceptibility to the biocide itself, to other biocidal agents or antibiotics (e.g. measured by a higher MIC value), a change of biofilm formation, a change of efflux pump activity or a change of horizontal gene transfer. Taking all the information together will hopefully allow to see that some antiseptic agents have a higher risk for microbial adaptation and resistance, and other agents have a lower risk.

Finally, a description of the frequency of resistance can be found, e.g. isolates with high MIC values, contaminated biocidal products or even outbreaks or pseudo-outbreaks of infections caused by contaminated biocidal products. Possible mechanisms of resistance are reviewed such as specific resistance genes, plasmids

and efflux pumps that may extrude deleterious compounds, such as antibiotics, drugs and solvents. Cross-resistance to other biocidal agents and antibiotics is also summarized in this part. Some studies have reported that a species became resistant to an antibiotic based on accepted break points and methods. In this case, an isolate will be described as resistant to the antibiotic. Other authors described an MIC change (e.g. by microdilution or Etest) or a change of the zone of inhibition (e.g. by disc diffusion test) without an assignment to “resistant” or “susceptible”. This type of finding will be described as cross-tolerance. In addition, data on biofilm development, removal and fixation are summarized for each antiseptic agent. Based on the agents’ summary, it should be possible to establish an antiseptic stewardship initiative.

Contents

1	Introduction	1
1.1	Background	1
1.2	Dimensions of Antiseptic Stewardship	3
1.3	Antiseptic Stewardship Per Type of Application	5
	References	5
2	Ethanol	9
2.1	Chemical Characterization	9
2.2	Types of Application	9
2.2.1	European Chemicals Agency (European Union)	10
2.2.2	Environmental Protection Agency (USA)	10
2.2.3	Food and Drug Administration (USA)	10
2.2.4	Overall Environmental Impact	11
2.3	Spectrum of Antimicrobial Activity	11
2.3.1	Bactericidal Activity	11
2.3.2	Fungicidal Activity	19
2.3.3	Mycobactericidal Activity	22
2.4	Effect of Low-Level Exposure	23
2.4.1	Bacteria	23
2.4.2	Yeasts	24
2.5	Resistance to Ethanol	24
2.5.1	Resistance Mechanisms	25
2.6	Cross-Tolerance to Other Biocidal Agents	25
2.7	Cross-Tolerance to Antibiotics	25
2.8	Role of Biofilm	25
2.8.1	Effect on Biofilm Development	25
2.8.2	Effect on Biofilm Removal	26
2.8.3	Effect on Biofilm Fixation	26
2.9	Summary	27
	References	29

3	Propan-1-ol	37
3.1	Chemical Characterization	37
3.2	Types of Application	37
3.2.1	European Chemicals Agency (European Union)	38
3.2.2	Environmental Protection Agency (USA)	38
3.2.3	Food and Drug Administration (USA)	38
3.2.4	Overall Environmental Impact	38
3.3	Spectrum of Antimicrobial Activity	39
3.3.1	Bactericidal Activity	39
3.3.2	Fungicidal Activity	40
3.3.3	Mycobactericidal Activity	40
3.4	Effect of Low-Level Exposure	41
3.5	Resistance to Propan-1-ol	41
3.5.1	Resistance Mechanisms	41
3.5.2	Resistance Genes	41
3.6	Cross-Tolerance to Other Biocidal Agents	41
3.7	Cross-Tolerance to Antibiotics	42
3.8	Role of Biofilm	42
3.8.1	Effect on Biofilm Development	42
3.8.2	Effect on Biofilm Removal	42
3.8.3	Effect on Biofilm Fixation	42
3.9	Summary	43
	References	44
4	Propan-2-ol	47
4.1	Chemical Characterization	47
4.2	Types of Application	47
4.2.1	European Chemicals Agency (European Union)	48
4.2.2	Environmental Protection Agency (USA)	48
4.2.3	Food and Drug Administration (USA)	48
4.2.4	Overall Environmental Impact	49
4.3	Spectrum of Antimicrobial Activity	49
4.3.1	Bactericidal Activity	49
4.3.2	Fungicidal Activity	54
4.3.3	Mycobactericidal Activity	55
4.4	Effect of Low-Level Exposure	55
4.5	Resistance to Propan-2-ol	56
4.5.1	Resistance Mechanisms	56
4.5.2	Resistance Genes	56
4.6	Cross-Tolerance to Other Biocidal Agents	56
4.7	Cross-Tolerance to Antibiotics	56
4.8	Role of Biofilm	57

4.8.1	Effect on Biofilm Development	57
4.8.2	Effect on Biofilm Removal	57
4.8.3	Effect on Biofilm Fixation	57
4.9	Summary	57
	References	58
5	Peracetic Acid	63
5.1	Chemical Characterization	63
5.2	Types of Application	63
5.2.1	European Chemicals Agency (European Union)	64
5.2.2	Environmental Protection Agency (USA)	64
5.2.3	Overall Environmental Impact	64
5.3	Spectrum of Antimicrobial Activity	65
5.3.1	Bactericidal Activity	65
5.3.2	Fungicidal Activity	77
5.3.3	Mycobactericidal Activity	79
5.4	Effect of Low-Level Exposure	83
5.5	Resistance to Peracetic Acid	83
5.5.1	Insufficient Efficacy in Suspension Tests	84
5.5.2	Persistence Despite Disinfection with Peracetic Acid as Recommended	84
5.5.3	Resistance Mechanisms	84
5.5.4	Resistance Genes	84
5.6	Cross-Tolerance to Other Biocidal Agents	86
5.7	Cross-Tolerance to Antibiotics	86
5.8	Role of Biofilm	86
5.8.1	Effect on Biofilm Development	87
5.8.2	Effect on Biofilm Removal	87
5.8.3	Effect on Biofilm Fixation	87
5.9	Summary	87
	References	90
6	Hydrogen Peroxide	99
6.1	Chemical Characterization	99
6.2	Types of Application	99
6.2.1	European Chemicals Agency (European Union)	100
6.2.2	Environmental Protection Agency (USA)	100
6.2.3	Overall Environmental Impact	100
6.3	Spectrum of Antimicrobial Activity	101
6.3.1	Bactericidal Activity	101
6.3.2	Fungicidal Activity	110
6.3.3	Mycobactericidal Activity	112

6.4	Effect of Low-Level Exposure	114
6.4.1	Bacteria	114
6.4.2	Yeasts	114
6.4.3	Mycobacteria	114
6.5	Resistance to Hydrogen Peroxide	117
6.5.1	Species with Resistance to Hydrogen Peroxide	117
6.5.2	Resistance Mechanisms	117
6.5.3	Resistance Genes	118
6.6	Cross-Tolerance to Other Biocidal Agents	119
6.7	Cross-Resistances to Antibiotics	119
6.8	Role of Biofilm	119
6.8.1	Effect on Biofilm Development	119
6.8.2	Effect on Biofilm Removal	120
6.8.3	Effect on Biofilm Fixation	121
6.9	Summary	121
	References	123
7	Glutaraldehyde	131
7.1	Chemical Characterization	131
7.2	Types of Application	131
7.2.1	European Chemicals Agency (European Union)	132
7.2.2	Environmental Protection Agency (USA)	132
7.2.3	Overall Environmental Impact	132
7.3	Spectrum of Antimicrobial Activity	133
7.3.1	Bactericidal Activity	133
7.3.2	Fungicidal Activity	139
7.3.3	Mycobactericidal Activity	140
7.4	Effect of Low-Level Exposure	144
7.5	Resistance to Glutaraldehyde	144
7.5.1	Bacteria	145
7.5.2	Mycobacteria	145
7.5.3	Resistance Mechanisms	148
7.5.4	Resistance Genes	149
7.6	Cross-Tolerance to Other Biocidal Agents	149
7.7	Cross-Tolerance to Antibiotics	150
7.8	Role of Biofilm	150
7.8.1	Effect on Biofilm Development	150
7.8.2	Effect on Biofilm Removal	150
7.8.3	Effect on Biofilm Fixation	151
7.9	Summary	151
	References	153

8	Sodium Hypochlorite	161
8.1	Chemical Characterization	161
8.2	Types of Application	161
8.2.1	European Chemicals Agency (European Union)	162
8.2.2	Environmental Protection Agency (USA)	162
8.2.3	Overall Environmental Impact	163
8.3	Spectrum of Antimicrobial Activity	163
8.3.1	Bactericidal Activity	163
8.3.2	Fungicidal Activity	181
8.3.3	Mycobactericidal Activity	186
8.4	Effect of Low-Level Exposure	188
8.5	Resistance to Sodium Hypochlorite	192
8.5.1	Resistance Mechanisms	193
8.5.2	Resistance Genes	193
8.6	Cross-Tolerance to Other Biocidal Agents	194
8.7	Cross-Tolerance to Antibiotics	194
8.8	Role of Biofilm	195
8.8.1	Effect on Biofilm Development	195
8.8.2	Effect on Biofilm Removal	196
8.8.3	Effect on Biofilm Fixation	198
8.9	Summary	198
	References	200
9	Triclosan	211
9.1	Chemical Characterization	211
9.2	Types of Application	211
9.2.1	European Chemicals Agency (European Union)	211
9.2.2	Environmental Protection Agency (USA)	212
9.2.3	Food and Drug Administration (USA)	212
9.2.4	Overall Environmental Impact	213
9.3	Spectrum of Antimicrobial Activity	213
9.3.1	Bactericidal Activity	213
9.3.2	Fungicidal Activity	219
9.3.3	Mycobactericidal Activity	223
9.4	Effect of Low-Level Exposure	223
9.5	Resistance to Triclosan	241
9.5.1	Resistance Mechanisms	241
9.5.2	Resistance Genes	242
9.5.3	Infections Associated with Resistance to Triclosan	242
9.6	Cross-Tolerance to Other Biocidal Agents	243
9.7	Cross-Tolerance to Antibiotics	243

9.8	Role of Biofilm	244
9.8.1	Effect on Biofilm Development	244
9.8.2	Effect on Biofilm Removal	245
9.8.3	Effect on Biofilm Fixation	245
9.9	Summary	245
	References	248
10	Benzalkonium Chloride	259
10.1	Chemical Characterization	259
10.2	Types of Application	259
10.2.1	European Chemicals Agency (European Union)	261
10.2.2	Environmental Protection Agency (USA)	261
10.2.3	Food and Drug Administration (USA)	261
10.2.4	Overall Environmental Impact	261
10.3	Spectrum of Antimicrobial Activity	262
10.3.1	Bactericidal Activity	262
10.3.2	Fungicidal Activity	284
10.3.3	Mycobactericidal Activity	286
10.4	Effect of Low-Level Exposure	288
10.5	Resistance to BAC	309
10.5.1	High MIC Values	310
10.5.2	Reduced Efficacy in Suspension Tests	310
10.5.3	Resistance Mechanisms	311
10.5.4	Resistance Genes	312
10.5.5	Cell Membrane Changes	327
10.5.6	Efflux Pumps	327
10.5.7	Plasmids for Resistance Transfer	328
10.5.8	Transposons for Resistance Transfer	330
10.5.9	Class I Integrons	330
10.5.10	Infections Associated with Contaminated BAC Solutions or Products	330
10.5.11	Contaminated BAC Solutions Without Evidence for Infections	334
10.6	Cross-Tolerance to Other Biocidal Agents	334
10.7	Cross-Tolerance to Antibiotics	335
10.8	Role of Biofilm	335
10.8.1	Effect on Biofilm Development	335
10.8.2	Effect on Biofilm Removal	337
10.8.3	Effect on Biofilm Fixation	337
10.9	Summary	337
	References	342

11 Didecyldimethylammonium Chloride	371
11.1 Chemical Characterization	371
11.2 Types of Application	371
11.2.1 European Chemicals Agency (European Union)	372
11.2.2 Environmental Protection Agency (USA)	372
11.2.3 Overall Environmental Impact	372
11.3 Spectrum of Antimicrobial Activity	372
11.3.1 Bactericidal Activity	373
11.3.2 Fungicidal Activity	379
11.3.3 Mycobactericidal Activity	379
11.4 Effect of Low-Level Exposure	379
11.5 Resistance to DDAC	386
11.5.1 Species with Resistance to DDAC	386
11.5.2 Resistance Mechanisms	386
11.5.3 Resistance Genes	388
11.5.4 Infections and Pseudo-Outbreaks Associated with Tolerance to DDAC	388
11.6 Cross-Tolerance to Other Biocidal Agents	388
11.7 Cross-Tolerance to Antibiotics	388
11.8 Role of Biofilm	389
11.8.1 Effect on Biofilm Development	389
11.8.2 Effect on Biofilm Removal	389
11.8.3 Effect on Biofilm Fixation	389
11.9 Summary	389
References	391
12 Polihexanide	395
12.1 Chemical Characterization	395
12.2 Types of Application	395
12.2.1 European Chemicals Agency (European Union)	396
12.2.2 Environmental Protection Agency (USA)	396
12.2.3 Overall Environmental Impact	396
12.3 Spectrum of Antimicrobial Activity	397
12.3.1 Bactericidal Activity	397
12.3.2 Fungicidal Activity	408
12.3.3 Mycobactericidal Activity	411
12.4 Effect of Low-Level Exposure	411
12.5 Resistance to PHMB	418
12.5.1 Species with Resistance to PHMB	418
12.5.2 Resistance Mechanisms	418
12.5.3 Resistance Genes	418
12.5.4 Infections Associated with Resistance to PHMB	418

12.6	Cross-Tolerance to Other Biocidal Agents	419
12.7	Cross-Tolerance to Antibiotics	419
12.8	Role of Biofilm	419
12.8.1	Effect on Biofilm Development	419
12.8.2	Effect on Biofilm Removal	419
12.8.3	Effect on Biofilm Fixation	420
12.9	Summary	420
	References	422
13	Chlorhexidine Digluconate	429
13.1	Chemical Characterization	429
13.2	Types of Application	429
13.2.1	European Chemicals Agency (European Union)	430
13.2.2	Food and Drug Administration (USA)	430
13.2.3	Overall Environmental Impact	430
13.3	Spectrum of Antimicrobial Activity	431
13.3.1	Bactericidal Activity	431
13.3.2	Fungicidal Activity	466
13.3.3	Mycobactericidal Activity	473
13.4	Effect of Low-Level Exposure	474
13.5	Resistance to Chlorhexidine	488
13.5.1	High MIC Values	488
13.5.2	Reduced Efficacy in Suspension Tests	489
13.5.3	Resistance Mechanisms	489
13.5.4	Resistance Genes	489
13.5.5	Cell Membrane Changes	491
13.5.6	Efflux Pumps	491
13.5.7	Plasmids	492
13.5.8	Class I Integrons	492
13.5.9	Infections Associated with Tolerance to Chlorhexidine	497
13.5.10	Bacterial Contamination of CHG Products or Solutions	497
13.6	Cross-Tolerance to Other Biocidal Agents	498
13.7	Cross-Tolerance to Antibiotics	498
13.8	Role of Biofilm	500
13.8.1	Effect on Biofilm Development	500
13.8.2	Effect on Biofilm Removal	502
13.8.3	Effect on Biofilm Fixation	503
13.9	Summary	504
	References	507

14	Octenidine Dihydrochloride	535
14.1	Chemical Characterization	535
14.2	Types of Application	535
14.2.1	European Medicines Agency (European Union)	536
14.2.2	Environmental Protection Agency (USA)	536
14.2.3	Food and Drug Administration (USA)	536
14.2.4	Overall Environmental Impact	536
14.3	Spectrum of Antimicrobial Activity	537
14.3.1	Bactericidal Activity	537
14.3.2	Fungicidal Activity	546
14.3.3	Mycobactericidal Activity	549
14.4	Effect of Low-Level Exposure	549
14.5	Resistance to OCT	549
14.5.1	High MIC Values	549
14.5.2	Reduced Efficacy in Suspension Tests	549
14.5.3	Resistance Mechanisms	551
14.5.4	Resistance Genes	551
14.6	Cross-Tolerance to Other Biocidal Agents	551
14.7	Cross-Tolerance to Antibiotics	551
14.8	Role of Biofilm	551
14.8.1	Effect on Biofilm Development	551
14.8.2	Effect on Biofilm Removal	551
14.8.3	Effect on Biofilm Fixation	554
14.9	Summary	554
	References	556
15	Silver	563
15.1	Chemical Characterization	563
15.2	Types of Application	563
15.2.1	European Chemicals Agency (European Union)	564
15.2.2	Environmental Protection Agency (USA)	564
15.2.3	Overall Environmental Impact	564
15.3	Spectrum of Antimicrobial Activity	565
15.3.1	Bactericidal Activity	565
15.3.2	Fungicidal Activity	573
15.3.3	Mycobactericidal Activity	575
15.4	Effect of Low-Level Exposure	575
15.5	Resistance to Silver	581
15.5.1	High MIC Values	581
15.5.2	Reduced Efficacy in Suspension Tests	582
15.5.3	Resistance Mechanisms	582
15.5.4	Resistance Genes	583

15.5.5	Efflux Pumps	586
15.5.6	Plasmids	586
15.5.7	Silver Uptake and Accumulation	588
15.6	Cross-Tolerance to Other Biocidal Agents	589
15.7	Cross-Tolerance to Antibiotics	589
15.7.1	Clinical Isolates	589
15.7.2	Environmental Isolates	589
15.7.3	Plasmids	590
15.8	Role of Biofilm	590
15.8.1	Effect on Biofilm Development	590
15.8.2	Effect on Biofilm Removal	593
15.8.3	Effect on Biofilm Fixation	594
15.9	Summary	594
	References	596
16	Povidone Iodine	609
16.1	Chemical Characterization	609
16.2	Types of Application	609
16.2.1	European Chemicals Agency (European Union)	610
16.2.2	Environmental Protection Agency (USA)	610
16.2.3	Food and Drug Administration (USA)	610
16.2.4	Overall Environmental Impact	611
16.3	Spectrum of Antimicrobial Activity	611
16.3.1	Bactericidal Activity	612
16.3.2	Fungicidal Activity	624
16.3.3	Mycobactericidal Activity	624
16.4	Effect of Low-Level Exposure	627
16.5	Resistance to Povidone Iodine	629
16.5.1	High MIC Values	629
16.5.2	Reduced Efficacy in Suspension Tests	629
16.5.3	Infections Associated with Contaminated Povidone Iodine Solutions or Products	630
16.5.4	Contaminated Povidone Iodine Solutions Without Evidence for Infections	630
16.5.5	Resistance Mechanisms	630
16.6	Cross-Tolerance to Other Biocidal Agents	630
16.7	Cross-Tolerance to Antibiotics	630
16.8	Role of Biofilm	631
16.8.1	Effect on Biofilm Development	631
16.8.2	Effect on Biofilm Removal	631
16.8.3	Effect on Biofilm Fixation	631
16.9	Summary	632
	References	634

17	Antiseptic Stewardship for Alcohol-Based Hand Rubs	643
17.1	Composition and Intended Use	643
17.2	Selection Pressure Associated with Commonly Used Biocidal Agents	643
17.2.1	Change of Susceptibility by Low-Level Exposure	643
17.2.2	Cross-Tolerance to Other Biocidal Agents	645
17.2.3	Cross-Tolerance to Antibiotics	646
17.2.4	Efflux Pump Genes	646
17.2.5	Horizontal Gene Transfer	646
17.2.6	Antibiotic Resistance Gene Expression	646
17.2.7	Viable but not Culturable	647
17.2.8	Other Risks Associated with Additional Biocidal Agents	647
17.3	Health Benefit of Biocidal Agents in Alcohol-Based Hand Rubs	647
17.4	Antiseptic Stewardship Implications	648
	References	649
18	Antiseptic Stewardship for Skin Antiseptics	651
18.1	Composition and Intended Use	651
18.2	Selection Pressure Associated with Commonly Used Biocidal Agents	651
18.2.1	Change of Susceptibility by Low-Level Exposure	651
18.2.2	Cross-Tolerance to Other Biocidal Agents	653
18.2.3	Cross-Tolerance to Antibiotics	653
18.2.4	Efflux Pump Genes	654
18.2.5	Horizontal Gene Transfer	654
18.2.6	Antibiotic Resistance Gene Expression	654
18.2.7	Other Risks Associated with Commonly Used Biocidal Agents	654
18.3	Effect on Biofilm	654
18.3.1	Biofilm Development	654
18.3.2	Biofilm Fixation	655
18.3.3	Biofilm Removal	655
18.4	Health Benefit of Commonly Used Biocidal Agents in Skin Antiseptics	656
18.5	Antiseptic Stewardship Implications	657
	References	659
19	Antiseptic Stewardship for Surface Disinfectants	661
19.1	Composition and Intended Use	661
19.2	Selection Pressure Associated with Commonly Used Biocidal Agents	661
19.2.1	Change of Susceptibility by Low-Level Exposure	661

19.2.2	Cross-Tolerance to Other Biocidal Agents	662
19.2.3	Cross-Tolerance to Antibiotics	663
19.2.4	Efflux Pump Genes	664
19.2.5	Resistance Gene Plasmids	664
19.2.6	Viable But Not Culturable	664
19.2.7	Horizontal Gene Transfer	664
19.2.8	Other Risks Associated with Biocidal Agents in Surface Disinfectants	664
19.3	Effect of Commonly Used Biocidal Agents on Biofilm	664
19.3.1	Biofilm Development	664
19.3.2	Biofilm Fixation	665
19.3.3	Biofilm Removal	666
19.4	Health Benefits of Biocidal Agents in Surface Disinfectants . . .	667
19.5	Antiseptic Stewardship Implications	667
	References	668
20	Antiseptic Stewardship for Instrument Disinfectants	671
20.1	Composition and Intended Use	671
20.2	Selection Pressure Associated with Commonly Used Biocidal Agents	671
20.2.1	Change of Susceptibility by Low-Level Exposure	671
20.2.2	Cross-Tolerance to Other Biocidal Agents	673
20.2.3	Cross-Tolerance to Antibiotics	673
20.2.4	Efflux Pump Genes	673
20.2.5	Resistance Gene Plasmids	673
20.2.6	Viable but not Culturable	673
20.2.7	Other Risks Associated with Biocidal Agents in Instrument Disinfectants	674
20.3	Effect of Commonly Used Biocidal Agents on Biofilm	674
20.3.1	Biofilm Development	674
20.3.2	Biofilm Fixation	674
20.3.3	Biofilm Removal	675
20.4	Expected Health Benefit of Biocidal Agents in Instrument Disinfectants	675
20.5	Antiseptic Stewardship Implications	676
	References	676
21	Antiseptic Stewardship for Antimicrobial Soaps	679
21.1	Composition and Intended Use	679
21.2	Selection Pressure Associated with Commonly Used Biocidal Agents	679
21.2.1	Change of Susceptibility by Low-Level Exposure	679
21.2.2	Cross-Tolerance to Other Biocidal Agents	681
21.2.3	Cross-Tolerance to Antibiotics	682

21.2.4	Efflux Pump Genes	682
21.2.5	Horizontal Gene Transfer	682
21.2.6	Antibiotic Resistance Gene Expression	682
21.2.7	Other Risks Associated with Biocidal Agents in Antimicrobial Soaps	682
21.3	Expected Health Benefit of Biocidal Agents in Antimicrobial Soaps	683
21.3.1	Antiseptic Body Wash Before Surgery	683
21.3.2	Antiseptic Body Wash for Patients on Intensive Care Units	683
21.3.3	Antiseptic Body Wash for Decolonization of MRSA	683
21.3.4	Surgical Scrubbing	684
21.3.5	Hygienic Hand Wash	684
21.4	Antiseptic Stewardship Implications	684
	References	685
22	Antiseptic Stewardship for Wound and Mucous Membrane Antiseptics	689
22.1	Composition and Intended Use	689
22.2	Selection Pressure Associated with Commonly Used Biocidal Agents	689
22.2.1	Change of Susceptibility by Low-Level Exposure	689
22.2.2	Cross-Tolerance to Other Biocidal Agents	690
22.2.3	Cross-Tolerance to Antibiotics	691
22.2.4	Efflux Pump Genes	691
22.2.5	Horizontal Gene Transfer	692
22.2.6	Antibiotic Resistance Gene Expression	692
22.2.7	Other Risks Associated with Biocidal Agents in Wound and Mucous Membrane Antiseptics	692
22.3	Effect of Commonly Used Biocidal Agents on Biofilm	692
22.3.1	Biofilm Development	692
22.3.2	Biofilm Fixation	692
22.3.3	Biofilm Removal	693
22.4	Health Benefits of Biocidal Agents in Wound and Mucous Membrane Antiseptics	694
22.5	Antiseptic Stewardship Implications	694
	References	694

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Abbreviations

3MRGN	Isolate with resistance to three of the following four antibiotic classes: acylureidopenicillins, third-generation and fourth-generation cephalosporins, carbapenems and fluoroquinolones
4MRGN	Isolate with resistance to all of the following four antibiotic classes: acylureidopenicillins, third-generation and fourth-generation cephalosporins, carbapenems and fluoroquinolones
<i>A. acidoterrestris</i>	<i>Alicyclobacillus acidoterrestris</i>
<i>A. actinomycetemcomitans</i>	<i>Aggregatibacter actinomycetemcomitans</i>
<i>A. alternata</i>	<i>Alternaria alternata</i>
<i>A. anitratus</i>	<i>Acinetobacter anitratus</i>
<i>A. aphrophilus</i>	<i>Aggregatibacter aphrophilus</i>
<i>A. baumannii</i>	<i>Acinetobacter baumannii</i>
<i>A. calcoaceticus</i>	<i>Acinetobacter calcoaceticus</i>
<i>A. delafieldii</i>	<i>Acidovorax delafieldii</i>
<i>A. elegans</i>	<i>Actinomucor elegans</i>
<i>A. ferrooxidans</i>	<i>Acidithiobacillus ferrooxidans</i>
<i>A. flavipes</i>	<i>Aspergillus flavipes</i>
<i>A. flavus</i>	<i>Aspergillus flavus</i>
<i>A. fumigatus</i>	<i>Aspergillus fumigatus</i>
<i>A. gyllenbergii</i>	<i>Acinetobacter gyllenbergii</i>
<i>A. hydrophila</i>	<i>Aeromonas hydrophila</i>
<i>A. israelii</i>	<i>Actinomyces israelii</i>
<i>A. jandaei</i>	<i>Aeromonas jandaei</i>
<i>A. junii</i>	<i>Acinetobacter junii</i>
<i>A. laidlawii</i>	<i>Acheloplasma laidlawii</i>
<i>A. lwoffii</i>	<i>Acinetobacter lwoffii</i>
<i>A. naeslundii</i>	<i>Actinomyces naeslundii</i>
<i>A. nidulans</i>	<i>Aspergillus nidulans</i>
<i>A. niger</i>	<i>Aspergillus niger</i>
<i>A. nosocomialis</i>	<i>Acinetobacter nosocomialis</i>
<i>A. ochraceus</i>	<i>Aspergillus ochraceus</i>

A. odontolyticus	Actinomyces odontolyticus
A. oleivorans	Acinetobacter oleivorans
A. parasiticus	Aspergillus parasiticus
A. proteolyticus	Aranicola proteolyticus
A. salmonicida	Aeromonas salmonicida
A. terreus	Aspergillus terreus
A. ustus	Aspergillus ustus
A. versicolor	Aspergillus versicolor
A. viscosus	Actinomyces viscosus
A. westerdijkiae	Aspergillus westerdijkiae
A. xylosoxidans	Achromobacter xylosoxidans
Ag-NP	Silver nanoparticles
ASTM	American Society for Testing and Materials
ATCC	American Type Culture Collection
B. abortus	Brucella abortus
B. adolescentis	Bifidobacterium adolescentis
B. afzelii	Borrelia afzelii
B. amyloliquefaciens	Bacillus amyloliquefaciens
B. animalis	Bifidobacterium animalis
B. bifidum	Bifidobacterium bifidum
B. breve	Bifidobacterium breve
B. burgdorferi	Borrelia burgdorferi
B. catenulatum	Bifidobacterium catenulatum
B. cenocepacia	Burkholderia cenocepacia
B. cepacia	Burkholderia cepacia
B. cereus	Bacillus cereus
B. diminuta	Brevundimonas diminuta
B. fragilis	Bacteroides fragilis
B. garinii	Borrelia garinii
B. gingivalis	Bacteroides gingivalis
B. infantis	Bifidobacterium infantis
B. intermedius	Bacteroides intermedius
B. licheniformis	Bacillus licheniformis
B. longum	Bifidobacterium longum
B. mallei	Burkholderia mallei
B. megaterium	Bacillus megaterium
B. melaninogenicus	Bacteroides melaninogenicus
B. melitensis	Brucella melitensis
B. petrii	Bordetella petrii
B. pseudocatenulatum	Bifidobacterium pseudocatenulatum
B. pseudolongum	Bifidobacterium pseudolongum
B. pseudomallei	Burkholderia pseudomallei
B. pumilus	Bacillus pumilus
B. sanguinis	Brevibacterium sanguinis
B. spicifera	Bipolaris spicifera

B. stearothermophilus	Bacillus stearothermophilus
B. subtilis	Bacillus subtilis
B. suis	Bifidobacterium suis
B. thailandensis	Burkholderia thailandensis
B. thermoacidophilum	Bifidobacterium thermoacidophilum
C. acidovorans	Comamonas acidovorans
C. albicans	Candida albicans
C. argentea	Candida argentea
C. ciferrii	Candida ciferrii
C. concisus	Campylobacter concisus
C. difficile	Clostridium difficile
C. diphtheriae	Corynebacterium diphtheriae
C. dubliniensis	Candida dubliniensis
C. famata	Candida famata
C. funicola	Chaetomium funicola
C. gingivalis	Capnocytophaga gingivalis
C. glabrata	Candida glabrata
C. globosum	Chaetomium globosum
C. guilliermondii	Candida guilliermondii
C. indologenes	Chryseobacterium indologenes
C. intermedia	Candida intermedia
C. intermedius	Citrobacter intermedius
C. jeikeium	Corynebacterium jeikeium
C. jejuni	Campylobacter jejuni
C. kefyr	Candida kefyr
C. koseri	Citrobacter koseri
C. krusei	Candida krusei
C. liriiodendri	Cylindrocarpon liriiodendri
C. lusitaniae	Candida lusitaniae
C. luteola	Chryseomonas luteola
C. macrodidymum	Cylindrocarpon macrodidymum
C. matruchotti	Corynebacterium matruchotti
C. melibiosica	Candida melibiosica
C. meningosepticum	Chryseobacterium meningosepticum
C. metallidurans	Cupriavidus metallidurans
C. neoformans	Cryptococcus neoformans
C. norvegensis	Candida norvegensis
C. novyi	Clostridium novyi
C. ochracea	Capnocytophaga ochracea
C. oleophila	Candida oleophila
C. orthopsilosis	Candida orthopsilosis
C. parapsilosis	Candida parapsilosis
C. pelliculosa	Candida pelliculosa
C. perfringens	Clostridium perfringens
C. piscicola	Carnobacterium piscicola

C. pseudogenitalium	Corynebacterium pseudogenitalium
C. pseudotropicalis	Candida pseudotropicalis
C. rectus	Campylobacter rectus
C. renale	Corynebacterium renale
C. rodentium	Citrobacter rodentium
C. sakazakii	Cronobacter sakazakii
C. sake	Candida sake
C. striatum	Corynebacterium striatum
C. trachomatis	Chlamydia trachomatis
C. tropicalis	Candida tropicalis
C. uniguttulatus	Cryptococcus uniguttulatus
C. utilis	Candida utilis
C. xerosis	Corynebacterium xerosis
CAS	Chemical abstracts service
CFU	Colony-forming units
CHA	Chlorhexidine diacetate
CHG	Chlorhexidine digluconate
CIP	Collection of Institut Pasteur
CMCC	National Center for Medical Culture Collections
CNS	Coagulase-negative staphylococci
D. acidovorans	Delftia acidovorans
D. hansenii	Debaryomyces hansenii
DSM	Deutsche Sammlung von Mikroorganismen
DT50	50% dissipation time
E. aerogenes	Enterobacter aerogenes
E. amylovora	Erwinia amylovora
E. asburiae	Enterobacter asburiae
E. avium	Enterococcus avium
E. casseliflavus	Enterococcus casseliflavus
E. cloacae	Enterobacter cloacae
E. coli	Escherichia coli
E. corrodens	Eikenella corrodens
E. durans	Enterococcus durans
E. faecalis	Enterococcus faecalis
E. gergoviae	Enterobacter gergoviae
E. hirae	Enterococcus hirae
E. ludwigii	Enterobacter ludwigii
E. nigrum	Epicoccum nigrum
E. nodatum	Eubacterium nodatum
E. raffinosus	Enterococcus raffinosus
E. repens	Eurotium repens
E. rhusiopathiae	Erysipelothrix rhusiopathiae
E. saccharolyticus	Enterococcus saccharolyticus
E. solitarius	Enterococcus solitarius
ECHA	European Chemicals Agency

ECOFF	Epidemiological cut-off value
EN	European norm
EPA	Environmental Protection Agency
ESBL	Extended spectrum β -lactamase
<i>F. alocis</i>	Filifactor alocis
<i>F. indologenes</i>	Flavobacterium indologenes
<i>F. lichenicola</i>	Fusarium lichenicola
<i>F. noatunensis</i>	Francisella noatunensis
<i>F. nucleatum</i>	Fusobacterium nucleatum
<i>F. oryzihabitans</i>	Flavimonas oryzihabitans
<i>F. oxysporum</i>	Fusarium oxysporum
<i>F. proliferatum</i>	Fusarium proliferatum
<i>F. psychrophilum</i>	Flavobacterium psychrophilum
<i>F. solani</i>	Fusarium solani
<i>F. tularensis</i>	Francisella tularensis
<i>F. verticillioides</i>	Fusarium verticillioides
FDA	Food and Drug Administration
<i>G. haemolysans</i>	Gemella haemolysans
<i>G. vaginalis</i>	Gardnerella vaginalis
h	Hour(s)
<i>H. alvei</i>	Hafnia alvei
<i>H. anomala</i>	Hansenula anomala
<i>H. burtonii</i>	Hyphopichia burtonii
<i>H. flavidus</i>	Humicoccus flavidus
<i>H. gallinarum</i>	Halonella gallinarum
<i>H. influenzae</i>	Haemophilus influenzae
<i>H. parainfluenzae</i>	Haemophilus parainfluenzae
<i>H. parasuis</i>	Haemophilus parasuis
<i>H. pylori</i>	Helicobacter pylori
<i>H. valbyensis</i>	Hanseniopsis valbyensis
ICU	Intensive care unit
IUPAC	International Union of Pure and Applied Chemistry
JCM	Japanese Collection of Microorganisms
<i>K. aerogenes</i>	Klebsiella aerogenes
<i>K. apiculata</i>	Kloeckera apiculata
<i>K. oxytoca</i>	Klebsiella oxytoca
<i>K. planticola</i>	Klebsiella planticola
<i>K. pneumoniae</i>	Klebsiella pneumoniae
<i>K. quasipneumoniae</i>	Klebsiella quasipneumoniae
<i>K. terrigena</i>	Klebsiella terrigena
<i>L. acidophilus</i>	Lactobacillus acidophilus
<i>L. amylovorus</i>	Lactobacillus amylovorus
<i>L. brevis</i>	Lactobacillus brevis
<i>L. brunescens</i>	Lysobacter brunescens
<i>L. bulgaricus</i>	Lactobacillus bulgaricus

<i>L. coryniformis</i>	<i>Lactobacillus coryniformis</i>
<i>L. fermentum</i>	<i>Lactobacillus fermentum</i>
<i>L. garvieae</i>	<i>Lactococcus garvieae</i>
<i>L. grayi</i>	<i>Listeria grayi</i>
<i>L. helveticus</i>	<i>Lactobacillus helveticus</i>
<i>L. innocua</i>	<i>Listeria innocua</i>
<i>L. lactis</i>	<i>Lactococcus lactis</i>
<i>L. mesenteroides</i>	<i>Leuconostoc mesenteroides</i>
<i>L. monocytogenes</i>	<i>Listeria monocytogenes</i>
<i>L. odontolyticus</i>	<i>Lactobacillus odontolyticus</i>
<i>L. paracasei</i>	<i>Lactobacillus paracasei</i>
<i>L. pentosus</i>	<i>Lactobacillus pentosus</i>
<i>L. plantarum</i>	<i>Lactobacillus plantarum</i>
<i>L. pneumophila</i>	<i>Legionella pneumophila</i>
<i>L. pseudomesenteroides</i>	<i>Leuconostoc pseudomesenteroides</i>
<i>L. reuteri</i>	<i>Lactobacillus reuteri</i>
<i>L. rhamnosus</i>	<i>Lactobacillus rhamnosus</i>
<i>L. salivarius</i>	<i>Lactobacillus salivarius</i>
<i>L. seeligeri</i>	<i>Listeria seeligeri</i>
<i>L. welshimeri</i>	<i>Listeria welshimeri</i>
<i>M. abscessus</i>	<i>Mycobacterium abscessus</i>
<i>M. adhaesivum</i>	<i>Methylobacterium adhaesivum</i>
<i>M. aquaticum</i>	<i>Methylobacterium aquaticum</i>
<i>M. avium</i>	<i>Mycobacterium avium</i>
<i>M. bolletii</i>	<i>Mycobacterium bolletii</i>
<i>M. bovis</i>	<i>Mycobacterium bovis</i>
<i>M. canis</i>	<i>Microsporium canis</i>
<i>M. chelonae</i>	<i>Mycobacterium chelonae</i>
<i>M. circinelloides</i>	<i>Mucor circinelloides</i>
<i>M. fortuitum</i>	<i>Mycobacterium fortuitum</i>
<i>M. frederiksbergense</i>	<i>Mycobacterium frederiksbergense</i>
<i>M. fructicola</i>	<i>Metschnikowia fructicola</i>
<i>M. furfur</i>	<i>Malassezia furfur</i>
<i>M. gallisepticum</i>	<i>Mycoplasma gallisepticum</i>
<i>M. gypseum</i>	<i>Microsporium gypseum</i>
<i>M. kansasii</i>	<i>Mycobacterium kansasii</i>
<i>M. luteus</i>	<i>Micrococcus luteus</i>
<i>M. marinum</i>	<i>Mycobacterium marinum</i>
<i>M. massiliense</i>	<i>Mycobacterium massiliense</i>
<i>M. morgani</i>	<i>Morganella morgani</i>
<i>M. nonchromogenicum</i>	<i>Mycobacterium nonchromogenicum</i>
<i>M. osloensis</i>	<i>Moraxella osloensis</i>
<i>M. pachydermatis</i>	<i>Malassezia pachydermatis</i>
<i>M. phlei</i>	<i>Mycobacterium phlei</i>
<i>M. phyllosphaeriae</i>	<i>Microbacterium phyllosphaeriae</i>

M. pneumoniae	Mycoplasma pneumoniae
M. racemosus	Mucor racemosus
M. rhodesianum	Methylobacterium rhodesianum
M. ruber	Monascus ruber
M. scrofulaceum	Mycobacterium scrofulaceum
M. slooffiae	Malassezia slooffiae
M. smegmatis	Mycobacterium smegmatis
M. suaveolens	Moniliella suaveolens
M. sympodialis	Malassezia sympodialis
M. terrae	Mycobacterium terrae
M. testaceum	Microbacterium testaceum
M. tuberculosis	Mycobacterium tuberculosis
M. xenopi	Mycobacterium xenopi
MBC	Minimum bactericidal concentration
MBEC	Minimum biofilm-eliminating concentration
MDR	Multidrug resistant
MIC	Minimum inhibitory concentration
MIC _{max}	Highest MIC value
min	Minute(s)
MRCNS	Methicillin-resistant coagulase-negative staphylococci
MRSA	Methicillin-resistant Staphylococcus aureus
MRSE	Methicillin-resistant Staphylococcus epidermidis
MRSP	Methicillin-resistant Staphylococcus pseudointermedius
MSCNS	Methicillin-susceptible coagulase-negative staphylococci
MSSA	Methicillin-susceptible Staphylococcus aureus
MSSP	Methicillin-susceptible Staphylococcus pseudointermedius
MTCC	Microbial Type Culture Collection and Gene Bank
N. asteroides	Nocardia asteroides
N. pseudofischeri	Neosartorya pseudofischeri
N. subflava	Neisseria subflava
NCIMB	National Collection of Industrial Food and Marine Bacteria
NCPF	National Collection of Pathogenic Fungi
NCTC	National Collection of Type Cultures
O. anthropi	Ochrobactrum anthropi
P	Commercial product
P. acnes	Propionibacterium acnes
P. aeruginosa	Pseudomonas aeruginosa
P. agglomerans	Pantoea agglomerans
P. alcalifaciens	Providencia alcalifaciens
P. aleophilum	Phaeoacremonium aleophilum

<i>P. alkylphenolia</i>	<i>Pseudomonas alkylphenolia</i>
<i>P. anaerobius</i>	<i>Peptostreptococcus anaerobius</i>
<i>P. ananatis</i>	<i>Pantoea ananatis</i>
<i>P. anomala</i>	<i>Pichia anomala</i>
<i>P. aurantiogriseum</i>	<i>Penicillium aurantiogriseum</i>
<i>P. caseifulvum</i>	<i>Penicillium caseifulvum</i>
<i>P. chlamydospora</i>	<i>Phaeomonella chlamydospora</i>
<i>P. chlororaphis</i>	<i>Pseudomonas chlororaphis</i>
<i>P. chrysogenum</i>	<i>Penicillium chrysogenum</i>
<i>P. citrinum</i>	<i>Penicillium citrinum</i>
<i>P. commune</i>	<i>Penicillium commune</i>
<i>P. corylophilum</i>	<i>Penicillium corylophilum</i>
<i>P. crustosum</i>	<i>Penicillium crustosum</i>
<i>P. denticola</i>	<i>Prevotella denticola</i>
<i>P. diminuta</i>	<i>Pseudomonas diminuta</i>
<i>P. discolor</i>	<i>Penicillium discolor</i>
<i>P. endodontalis</i>	<i>Porphyromonas endodontalis</i>
<i>P. expansum</i>	<i>Penicillium expansum</i>
<i>P. fluorescens</i>	<i>Pseudomonas fluorescens</i>
<i>P. fragi</i>	<i>Pseudomonas fragi</i>
<i>P. gingivalis</i>	<i>Porphyromonas gingivalis</i>
<i>P. intermedia</i>	<i>Prevotella intermedia</i>
<i>P. lundensis</i>	<i>Pseudomonas lundensis</i>
<i>P. marginalis</i>	<i>Pseudomonas marginalis</i>
<i>P. melaninogenica</i>	<i>Prevotella melaninogenica</i>
<i>P. mexicana</i>	<i>Pseudoxanthomonas mexicana</i>
<i>P. micra</i>	<i>Parvimonas micra</i>
<i>P. micros</i>	<i>Peptostreptococcus micros</i>
<i>P. mirabilis</i>	<i>Proteus mirabilis</i>
<i>P. morgani</i>	<i>Proteus morgani</i>
<i>P. multocida</i>	<i>Pasteurella multocida</i>
<i>P. nalgiovense</i>	<i>Penicillium nalgiovense</i>
<i>P. nigrescens</i>	<i>Prevotella nigrescens</i>
<i>P. nitroreducens</i>	<i>Pseudomonas nitroreducens</i>
<i>P. nitroreductans</i>	<i>Pseudomonas nitroreductans</i>
<i>P. norvegensis</i>	<i>Pichia norvegensis</i>
<i>P. ohmeri</i>	<i>Pichia ohmeri</i>
<i>P. paneum</i>	<i>Penicillium paneum</i>
<i>P. putida</i>	<i>Pseudomonas putida</i>
<i>P. pyocyanea</i>	<i>Pseudomonas pyocyanea</i>
<i>P. rettgeri</i>	<i>Proteus rettgeri</i>
<i>P. roqueforti</i>	<i>Penicillium roqueforti</i>
<i>P. solitum</i>	<i>Penicillium solitum</i>
<i>P. stutzeri</i>	<i>Pseudomonas stutzeri</i>
<i>P. verrucosum</i>	<i>Penicillium verrucosum</i>

<i>P. vesicularis</i>	<i>Pseudomonas vesicularis</i>
<i>P. vulgaris</i>	<i>Proteus vulgaris</i>
PRSP	Penicillin-resistant <i>Streptococcus pneumoniae</i>
PTFE	Polytetrafluoroethylene
PVC	Polyvinyl chloride
QAC	Quaternary ammonium compound
<i>R. dentocariosa</i>	<i>Rothia dentocariosa</i>
<i>R. erythropolis</i>	<i>Rhodococcus erythropolis</i>
<i>R. microsporus</i>	<i>Rhizopus microsporus</i>
<i>R. mucilaginosus</i>	<i>Rhodotorula mucilaginosa</i>
<i>R. nigricans</i>	<i>Rhizopus nigricans</i>
<i>R. pickettii</i>	<i>Ralstonia pickettii</i>
<i>R. planticola</i>	<i>Raoultella planticola</i>
<i>R. rubra</i>	<i>Rhodotorula rubra</i>
<i>R. rubrum</i>	<i>Rhodospirillum rubrum</i>
S	Solution of antiseptic agent
s	Second(s)
<i>S. Anatum</i>	<i>Salmonella Anatum</i>
<i>S. anginosus</i>	<i>Streptococcus anginosus</i>
<i>S. apiospermum</i>	<i>Scedosporium apiospermum</i>
<i>S. arboriculus</i>	<i>Saccharomyces arboriculus</i>
<i>S. aureus</i>	<i>Staphylococcus aureus</i>
<i>S. bayanus</i>	<i>Saccharomyces bayanus</i>
<i>S. brevicaulis</i>	<i>Scopulariopsis brevicaulis</i>
<i>S. capitis</i>	<i>Staphylococcus capitis</i>
<i>S. caprae</i>	<i>Staphylococcus caprae</i>
<i>S. cariocanus</i>	<i>Saccharomyces cariocanus</i>
<i>S. carlsbergensis</i>	<i>Saccharomyces carlsbergensis</i>
<i>S. cerevisiae</i>	<i>Saccharomyces cerevisiae</i>
<i>S. choleraesuis</i>	<i>Salmonella choleraesuis</i>
<i>S. chromogenes</i>	<i>Staphylococcus chromogenes</i>
<i>S. cohnii</i>	<i>Staphylococcus cohnii</i>
<i>S. constellatus</i>	<i>Streptococcus constellatus</i>
<i>S. delphini</i>	<i>Staphylococcus delphini</i>
<i>S. enterica</i>	<i>Salmonella enterica</i>
<i>S. Enteritidis</i>	<i>Salmonella Enteritidis</i>
<i>S. epidermidis</i>	<i>Staphylococcus epidermidis</i>
<i>S. equorum</i>	<i>Staphylococcus equorum</i>
<i>S. fleurettii</i>	<i>Staphylococcus fleurettii</i>
<i>S. flexneri</i>	<i>Shigella flexneri</i>
<i>S. gordonii</i>	<i>Streptococcus gordonii</i>
<i>S. Hadar</i>	<i>Salmonella Hadar</i>
<i>S. haemolyticus</i>	<i>Staphylococcus haemolyticus</i>
<i>S. hominis</i>	<i>Staphylococcus hominis</i>
<i>S. hyicus</i>	<i>Staphylococcus hyicus</i>

<i>S. infantis</i>	<i>Salmonella infantis</i>
<i>S. intermedius</i>	<i>Streptococcus intermedius</i>
<i>S. Kentucky</i>	<i>Salmonella Kentucky</i>
<i>S. kloosii</i>	<i>Staphylococcus kloosii</i>
<i>S. kudriavzevii</i>	<i>Saccharomyces kudriavzevii</i>
<i>S. lentus</i>	<i>Staphylococcus lentus</i>
<i>S. liquefaciens</i>	<i>Serratia liquefaciens</i>
<i>S. lugdunensis</i>	<i>Staphylococcus lugdunensis</i>
<i>S. maltophilia</i>	<i>Stenotrophomonas maltophilia</i>
<i>S. marcescens</i>	<i>Serratia marcescens</i>
<i>S. mikatae</i>	<i>Saccharomyces mikatae</i>
<i>S. mitis</i>	<i>Streptococcus mitis</i>
<i>S. mizutae</i>	<i>Sphingobacterium mizutae</i>
<i>S. multivorum</i>	<i>Sphingobacterium multivorum</i>
<i>S. mutans</i>	<i>Streptococcus mutans</i>
<i>S. oralis</i>	<i>Streptococcus oralis</i>
<i>S. paradoxus</i>	<i>Saccharomyces paradoxus</i>
<i>S. parasanguinis</i>	<i>Streptococcus parasanguinis</i>
<i>S. pasteurii</i>	<i>Staphylococcus pasteurii</i>
<i>S. paucimobilis</i>	<i>Sphingomonas paucimobilis</i>
<i>S. pneumoniae</i>	<i>Streptococcus pneumoniae</i>
<i>S. pombe</i>	<i>Schizosaccharomyces pombe</i>
<i>S. proteamaculans</i>	<i>Serratia proteamaculans</i>
<i>S. pseudintermedius</i>	<i>Staphylococcus pseudintermedius</i>
<i>S. putrefaciens</i>	<i>Shewanella putrefaciens</i>
<i>S. pyogenes</i>	<i>Streptococcus pyogenes</i>
<i>S. salivarius</i>	<i>Streptococcus salivarius</i>
<i>S. sanguinis</i>	<i>Streptococcus sanguinis</i>
<i>S. sanguis</i>	<i>Streptococcus sanguis</i>
<i>S. saprophyticus</i>	<i>Staphylococcus saprophyticus</i>
<i>S. schleiferi</i>	<i>Staphylococcus schleiferi</i>
<i>S. sciuri</i>	<i>Staphylococcus sciuri</i>
<i>S. Senftenberg</i>	<i>Salmonella Senftenberg</i>
<i>S. simulans</i>	<i>Staphylococcus simulans</i>
<i>S. sobrinus</i>	<i>Streptococcus sobrinus</i>
<i>S. soli</i>	<i>Sphingomonas soli</i>
<i>S. sonnei</i>	<i>Shigella sonnei</i>
<i>S. spiritivorum</i>	<i>Sphingobacterium spiritivorum</i>
<i>S. thermophilus</i>	<i>Streptococcus thermophilus</i>
<i>S. Thompson</i>	<i>Salmonella Thompson</i>
<i>S. Typhimurium</i>	<i>Salmonella Typhimurium</i>
<i>S. uvarum</i>	<i>Saccharomyces uvarum</i>
<i>S. viridians</i>	<i>Streptococcus viridians</i>
<i>S. warneri</i>	<i>Staphylococcus warneri</i>
<i>S. wittichii</i>	<i>Sphingomonas wittichii</i>

S. xiamenensis	Shewanella xiamenensis
S. xylosus	Staphylococcus xylosus
S. yanoikuyae	Sphingobium yanoikuyae
SCCS	Scientific Committee on Consumer Safety
SEM	Scanning electron microscopy
t	Ton(s)
T. asahii	Trichosporon asahii
T. delbrueckii	Torulaspora delbrueckii
T. forsythia	Tannerella forsythia
T. harzianum	Trichoderma harzianum
T. longibrachiatum	Trichoderma longibrachiatum
T. mentagrophytes	Trichophyton mentagrophytes
T. rubrum	Trichophyton rubrum
T. viride	Trichoderma viride
T. whipplei	Tropheryma whipplei
V. alginolyticus	Vibrio alginolyticus
V. atypica	Veillonella atypica
V. cholerae	Vibrio cholerae
V. dispar	Veillonella dispar
V. indigofera	Vogesella indigofera
V. parahaemolyticus	Vibrio parahaemolyticus
V. parvula	Veillonella parvula
V. vulnificus	Vibrio vulnificus
v/v	Volume by volume
VBNC	Viable but non-culturable
VISA	Vancomycin intermediate-resistant <i>Staphylococcus aureus</i>
WISE	Vancomycin intermediate-resistant <i>Staphylococcus epidermidis</i>
VRE	Vancomycin-resistant <i>Enterococcus</i> spp.
w/w	Weight by weight
WD	Washer disinfectant
WHO	World Health Organization
X. aerolatus	Xenophilus aerolatus
X. citri	Xanthomonas citri
X. maltophilia	Xanthomonas maltophilia
Y. enterocolitica	Yersinia enterocolitica
Y. pestis	Yersinia pestis
Y. pseudotuberculosis	Yersinia pseudotuberculosis
Y. ruckeri	Yersinia ruckeri

List of Figures

Fig. 2.1 SEM images of 48-h biofilm formed by an *S. aureus* isolate in medium (control) or 1.25% ethanol. Arrows: extracellular matrix [24]. Reproduced in parts without change from Cincarova L, Polansky O, Babak V, Kulich P, Kralik P. Changes in the Expression of Biofilm-Associated Surface Proteins in *Staphylococcus aureus* Food-Environmental Isolates Subjected to Sublethal Concentrations of Disinfectants. *BioMed Research International* 2016:4034517. <https://doi.org/10.1155/2016/4034517>. This is an open-access article distributed under the Creative Commons Attribution License 23

Fig. 8.1 Scanning electron micrographs (a) and transmission electron micrographs (b) of *L. monocytogenes* strains (ATCC 19112). O-strain represents original strains grown in TSB without disinfectant. T-strain represents strains adapted to chloramines-T. Na-strain represents strains adapted to sodium hypochlorite [63]; Reprinted from Food Control, Volume number 46, Authors Gao H and Liu C, Biochemical and morphological alteration of *Listeria monocytogenes* under environmental stress caused by chloramine-T and sodium hypochlorite, pp. 455–461, Copyright 2014, with permission from Elsevier 192

Fig. 10.1 Pathways and mechanisms of QAC resistance [376]. Reprinted from Current Opinion in Biotechnology, Volume number 33, Authors Tezel U and Pavlostathis SG, Quaternary ammonium disinfectants: microbial adaptation, degradation and ecology, pp. 296–304, Copyright 2015, with permission from Elsevier 311

Fig. 15.1 Antimicrobial effects of Ag⁺. Interaction with membrane proteins and blocking respiration and electron transfer; inside the cell, Ag⁺ ions interact with DNA, proteins and induce reactive oxygen species production [93]. Reprinted by

permission from Springer Nature, *Biomaterials* (Mijnendonckx K, Leys N, Mahillon J, Silver S, Van Houdt R. Antimicrobial silver: uses, toxicity and potential for resistance. *Biomaterials*. 2013; 26: 609–21) 566

Fig. 15.2 Genetic architecture of the *sil* operon [123]; reproduced in parts without change from Randall CP, Gupta A, Jackson N, Busse D, O’Neill AJ. Silver resistance in Gram-negative bacteria: a dissection of endogenous and exogenous mechanisms. *J Antimicrob Chemother*. 2015; 70: 1037–46; the article is distributed under the terms of the Creative Commons CC BY licence. 583

Fig. 17.1 Number of species with no, a weak or a strong adaptive MIC increase after low-level exposure to biocidal agents that may be found in alcohol-based hand rubs 644

Fig. 18.1 Number of species with no, a weak or a strong adaptive MIC increase after low level exposure to biocidal agents that may be found in skin antiseptics 652

Fig. 18.2 Number of species with a decrease or increase of biofilm formation caused by biocidal agents that may be found in skin antiseptics 655

Fig. 18.3 Number of species with a strong ($\geq 90\%$), moderate (10–89%) or poor biofilm removal ($<10\%$) by biocidal agents that may be found in skin antiseptics. 656

Fig. 19.1 Number of species with no, a weak or a strong adaptive MIC increase after low-level exposure to biocidal agents typically found in surface disinfectants. 662

Fig. 19.2 Schematic of surface attachment, biofilm formation and biocide susceptibility [17]. Reprinted from the *Journal of Hospital Infection*, Volume number 89, Issue number 1, Authors Otter JA, Vickery K, Walker JT, deLancey Pulcini E, Stoodley P, Goldenberg SD et al., Surface-attached cells, biofilms and biocide susceptibility: implications for hospital cleaning and disinfection, Pages 16–27, Copyright 2015, with permission from Elsevier 665

Fig. 19.3 Number of species with a decrease or increase of biofilm formation caused by biocidal agents that may be found in surface disinfectants 666

Fig. 19.4 Number of species with a strong ($\geq 90\%$), moderate (10–89%) or poor biofilm removal ($<10\%$) by biocidal agents that may be found in surface disinfectants. 666

Fig. 20.1 Number of species with no, a weak or a strong adaptive MIC increase after low-level exposure to biocidal agents that may be found in instrument disinfectants. 672

Fig. 20.2	Number of species with a decrease or increase of biofilm formation caused by biocidal agents that may be found in instrument disinfectants	674
Fig. 20.3	Number of species with a strong ($\geq 90\%$), moderate (10–89%) or poor biofilm removal (<10%) by biocidal agents that may be found in instrument disinfectants	675
Fig. 21.1	Number of species with no, a weak or a strong adaptive MIC increase after low-level exposure to biocidal agents that may be found in antiseptic soaps	680
Fig. 22.1	Number of species with no, a weak or a strong adaptive MIC increase after low-level exposure to biocidal agents that may be found in wound or mucous membrane antiseptics	690
Fig. 22.2	Number of species with a decrease or increase of biofilm formation caused by biocidal agents that may be found in wound or mucous membrane antiseptics.	693
Fig. 22.3	Number of species with a strong ($\geq 90\%$), moderate (10–89%) or poor biofilm removal (<10%) by biocidal agents that may be found in wound or mucous membrane antiseptics	693