NATIONAL INSTITUTE
FOR HEALTH AND WELFARE

Marianne Gunell
Jari Jalava

DISCUSSION PAPER

Antimicrobial Resistance in Finland

Finres 2012

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FINNISH STUDY GROUP FOR ANTIMICROBIAL RESISTANCE

FiRe

SUOMALAINEN MIKROBILÄÄKERESISTENSSIN TUTKIMUSRYHMÄ

NATIONAL INSTITUTE
FOR HEALTH AND WELFARE

Editors: Marianne Gunell and Jari Jalava.

Authors: Marianne Gunell (THL), Antti Hakanen, Jari Jalava (THL), Antti Nissinen, Kaisu Rantakokko-Jalava, Kerttu Saha, Jaana Vuopio, Anne-Mari Rissanen, Martti Vaara, Jaana Kauppila, and Janne Aittoniemi.

Finres 2012 data concerning microbiology were collected and checked by Antti Nissinen. Contact persons for the Finres database are Antti Leinonen (THL), Jere Veltheim (THL) and Teemu Möttönen (THL).

In 2008–2012, susceptibility data were submitted by the following laboratories (the 2012 contact person in brackets):
Carea/Kymenlaakso (Benita Forsblom and Ulla Larinkari);
Eksote/Etelä-Karjala (Maritta Kauppinen);
Fimlab/Hämeenlinna (Marjukka Härkönen);
Fimlab/Tampere (Janne Aittoniemi, Marjukka Härkönen and Risto Vuento);
HUSLAB (Martti Vaara and Eveliina Tarkka);
ISLAB/Joensuu (Jari Karhukorpi and Pirkko Hautala);
ISLAB/KYS (Ulla Kärkkäinen and Anne-Mari Rissanen);
ISLAB/Mikkeli and Savonlinna central hospital (Tamara Tuuminen and Päivi Suomala);
KESLAB/Keski-Suomi central hospital (Antti Nissinen and Jaakko Uksila);
NordLab Kajaani (Pekka Ruuska);
NordLab Kemi (Martti Larikka);
NordLab Kokkola (Maaret Suokas and Markku Koskela);
NordLab Oulu (Jaana Kauppila and Jari Kauranen);
NordLab Rovaniemi (Joanna Peltola);
Phsotey/Päijät-Häme (Hannu Sarkkinen and Pauliina Kärpänoja);
SataDiag (Raija Manninen);
Seinäjoki Central Hospital (Sinikka Oinonen and Kerttu Saha);
Terveystalo Pulssi (Tytti Vuorinen);
TYKSLAB (Olli Meurman and Kaisu Rantakokko-Jalava);
UTULab (Erkki Eerola and Antti Hakanen);
Vaasa Central Hospital (Suvi-Sirkku Kaukoranta and Jari Hirvonen);
VITA-Terveyspalvelut (Päivi Kankkunen);
Yhtyneet Medix Laboratoriot (Anna Muotiala and Timo Walle).

FiRe board members in 2012: Antti Nissinen (chair), Janne Aittoniemi, Jaana Kauppila, Kaisu Rantakokko-Jalava, Anne-Mari Rissanen, Kerttu Saha and Martti Vaara.

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Foreword

The nationwide resistance surveillance of a wide variety of antimicrobial agents and bacterial species is based on the routine antimicrobial susceptibility testing by clinical microbiology laboratories (FiRe laboratories). The data are collated into the Finres database maintained by the National Institute for Health and Welfare (THL). This Finres 2012 report is based on the data recorded in the database and covers the antimicrobial susceptibility data on the 15 clinically most important bacterial species isolated from clinical samples in 2008–2012. The report is published in THL's publication series Discussion Paper.

Several FiRe laboratories, all listed in this report, took part in the production of susceptibility data in 2008–2012. The collection and checking of data as well as the development and maintenance of the Finres database were carried out by a number of persons, all named in the report. We would like to thank all those who took part in the production, collection and checking of antimicrobial susceptibility data as well as all those who helped in writing this report.

Turku, 13 December 2013

The editors

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Introduction

Antimicrobial resistance is usually determined by using standard clinical breakpoints. In this report, antimicrobial resistance in different years was determined on the basis of the EUCAST clinical breakpoints valid for the year in question. In 2011–2012, the clinical breakpoints used in the laboratories were the versions 1.3 (in 2011) and 2.0 (in 2012) of the EUCAST clinical breakpoint tables for bacteria, while in 2008–2010 the applied clinical breakpoints were based on the CLSI standards for antimicrobial susceptibility testing. As a general rule, data are expressed as the proportion of resistant (R) strains out of the first findings of the specific bacterial species in each patient. For some antimicrobial agents, data are given as the proportion of both resistant (R) and non-susceptible (RI) strains out of all strains. To avoid bias, resistance percentages are, with a few exceptions, given to those bacterium–antimicrobial combinations where more than half of all isolates were tested.

Since 2011, all FiRe laboratories have been using the European EUCAST standard. This transition has had some impact on the clinical breakpoints used to categorise a bacterial strain as susceptible (S) or resistant (R) and, therefore, also on the proportions of non-susceptible and resistant strains for certain bacterial species and antimicrobials. As a result, the resistance levels in 2011 and 2012 are not fully comparable with all data on previous years. This is taken into account in the report.

Another effect of the EUCAST transition is that for some antimicrobial groups the tested antimicrobial agent may have changed. For example, cefalothin was previously used to represent the group of first-generation cephalosporins, while EUCAST has clinical breakpoints only for cefalexin. Similarly, the antimicrobials tested in the group of fluoroquinolones were previously norfloxacin, levofloxacin and ciprofloxacin, but especially in 2012 most of the FiRe laboratories have used ciprofloxacin as a representative of the group.

In the figures, abbreviations are used for the antimicrobials, and these are explained in the annex at the end of the report. As a rule, bacteria are identified by their scientific names, and any exceptions to this are explained in the text. Also, resistance data are generally presented by species, with the exception of *Acinetobacter*, which is not categorised by species in the Finres database.

Summary

The Finres 2012 report shows that the susceptibility of the clinically most important bacteria against the most significant antimicrobials in use has remained at a relatively high level in Finland. However, there are signs that antimicrobial resistance develops at a different speed for different bacterial groups. Resistance in gram-negative bacilli to beta-lactams seems to be on the rise. Especially, the number of *Escherichia coli* strains that produce extended-spectrum beta-lactamases (ESBL) has been increasing steadily during the five-year period. Carbapenem-resistant strains among *Enterobacteriaceae* are rare for the present. The number of methicillin-resistant *Staphylococcus aureus* (MRSA) strains has remained at the same, relatively low level. The proportion of penicillin-non-susceptible (RI) *Streptococcus pneumoniae* strains was increasing until 2010 in all clinical samples and age groups. After 2010, there seems to have been a change for the better concerning penicillin- and macrolide-resistant *S. pneumoniae* strains isolated from pus samples that were obtained from children aged under 5. It remains to be seen whether this positive trend continues in future. *Streptococcus pyogenes* is still relatively susceptible to macrolides and clindamycin, although in 2012 there was a clear increase in the number of resistant strains isolated from pus specimens.

Antimicrobial resistance

1. *Acinetobacter* spp.

The FiRe laboratories examined 1 847 strains of *Acinetobacter* spp. in 2012. A total of 1 189 of these were isolated from pus samples.

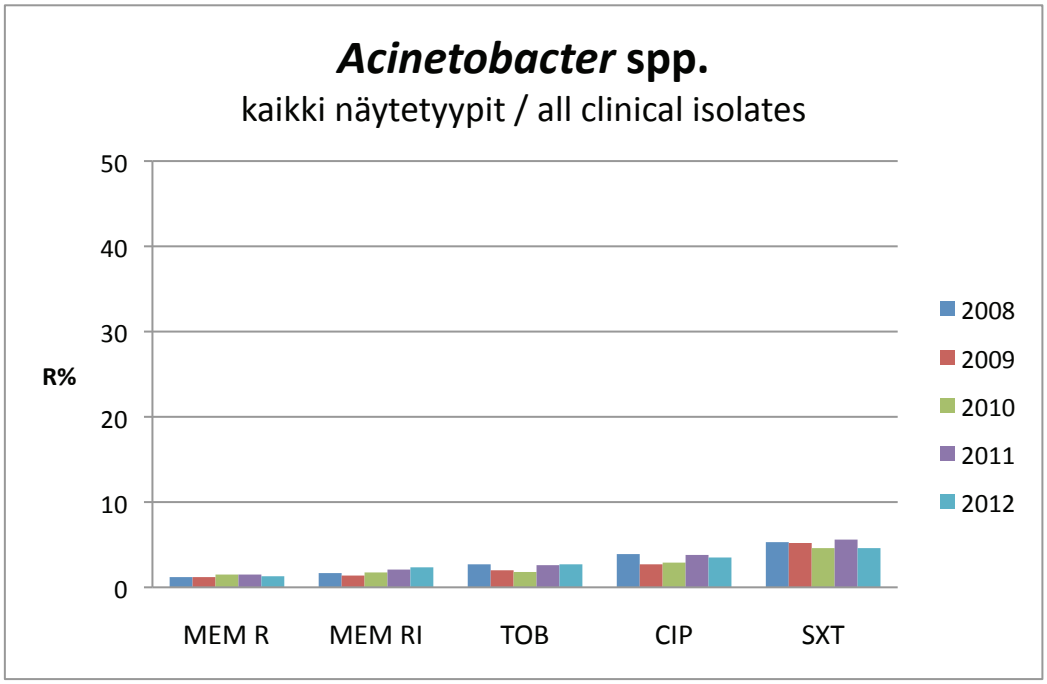

Figure 1. Antimicrobial resistance in *Acinetobacter* in 2008–2012.

Acinetobacter has intrinsic resistance to most antimicrobials. Figure 1 describes the resistance in *Acinetobacter* strains against certain antimicrobials to which the bacterium has intrinsic susceptibility. *Acinetobacter* strains isolated in Finland have remained relatively susceptible. It is noteworthy that meropenem resistance has remained low in Finland (Table 1), although carbapenem-resistant strains cause problems across Europe. In certain countries (Greece, Israel, Italy, Latvia, Lithuania, and Croatia), carbapenem-resistant *Acinetobacter* strains are endemic. Emergence of carbapenem-resistant strains is a serious problem for hospital hygiene.

Table 1. Numbers and resistance percentages of *Acinetobacter* strains.

Antimicrobial		**2008**	**2009**	**2010**	**2011**	**2012**
Meropenem	tested	1 317	1 375	1 489	1 967	1 491
	R%	1.2	1.2	1.5	1.5	1.3
	RI%	1.7	1.4	1.7	2.1	2.3
Tobramycin	tested	1992	1978	1 981	2 184	1 767
	R%	2.7	2.0	1.8	2.6	2.7
Ciprofloxacin	tested	1 658	1 796	1 535	1 630	1 342
	R%	3.9	2.7	2.9	3.8	3.5
Trimethoprim-sulfa	tested	2 122	2 084	1 885	2 088	1 834
	R%	5.3	5.2	4.6	5.6	4.6

2. *Enterobacter cloacae*

The FiRe laboratories examined 4 808 *Enterobacter cloacae* strains in 2012. A total of 2 550 of these were isolated from urine samples.

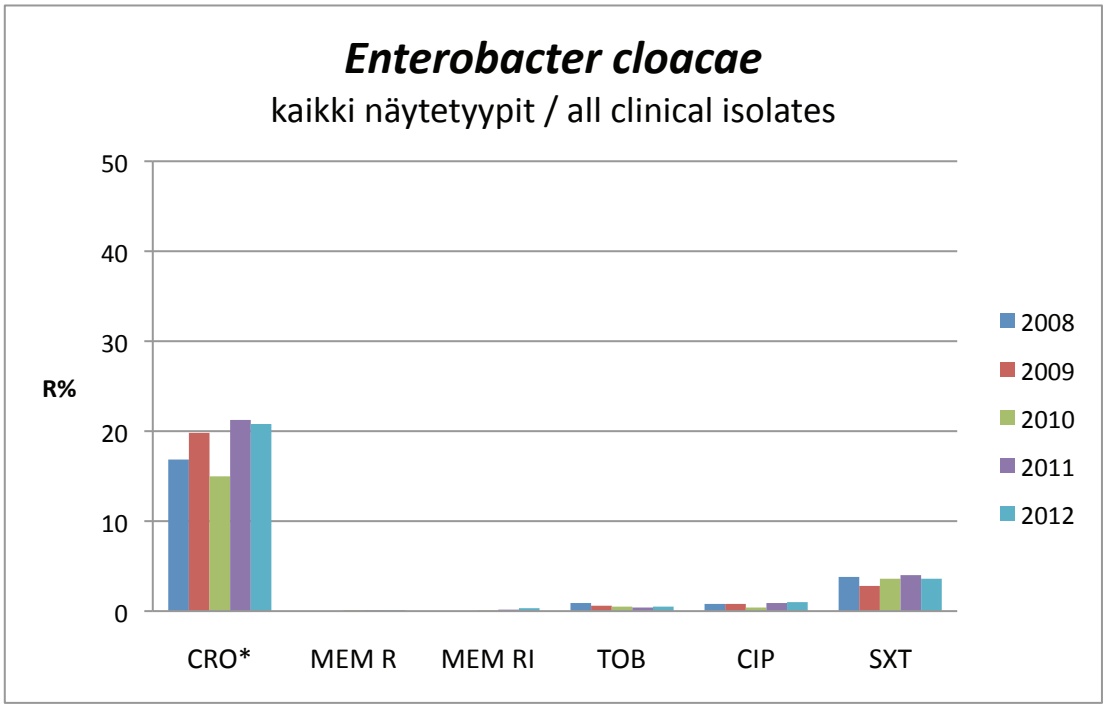

Figure 2. Antimicrobial resistance in *E. cloacae* in 2008–2012 (*Data on ceftriaxone are based on results from eight FiRe laboratories; other laboratories have not tested susceptibility to ceftriaxone.)

Apart from ceftriaxone resistance, *E. cloacae* strains have remained relatively susceptible to the most important antimicrobials in use. Due to the natural chromosomal AmpC beta-lactamase, *E. cloacae* develops easily resistance to third-generation cephalosporins especially in connection with cephalosporin monotherapy. The number of meropenem-resistant strains has been very low, under five strains per year.

Table 2. Numbers and resistance percentages of *E. cloacae* strains.

Antimicrobial		**2008**	**2009**	**2010**	**2011**	**2012**
Ceftriaxone	tested	730	1 181	1 355	1 313	1 457
	R%	16.8	19.8	15.0	21.2	20.8
Meropenem	tested	1 869	2 069	2 611	3 049	3 392
	R%	-	-	0.1	0.1	0.1
	RI%	-	-	0.1	0.2	0.3
Tobramycin	tested	2 606	2 706	3 000	3 146	3 345
	R%	0.9	0.6	0.5	0.4	0.5
Ciprofloxacin	tested	2 714	2 786	2 956	2 733	2 710
	R%	0.8	0.8	0.4	0.9	1
Trimethoprim-sulfa	tested	3 124	3 136	2 893	2 785	3 293
	R%	3.8	2.8	3.6	4	3.6

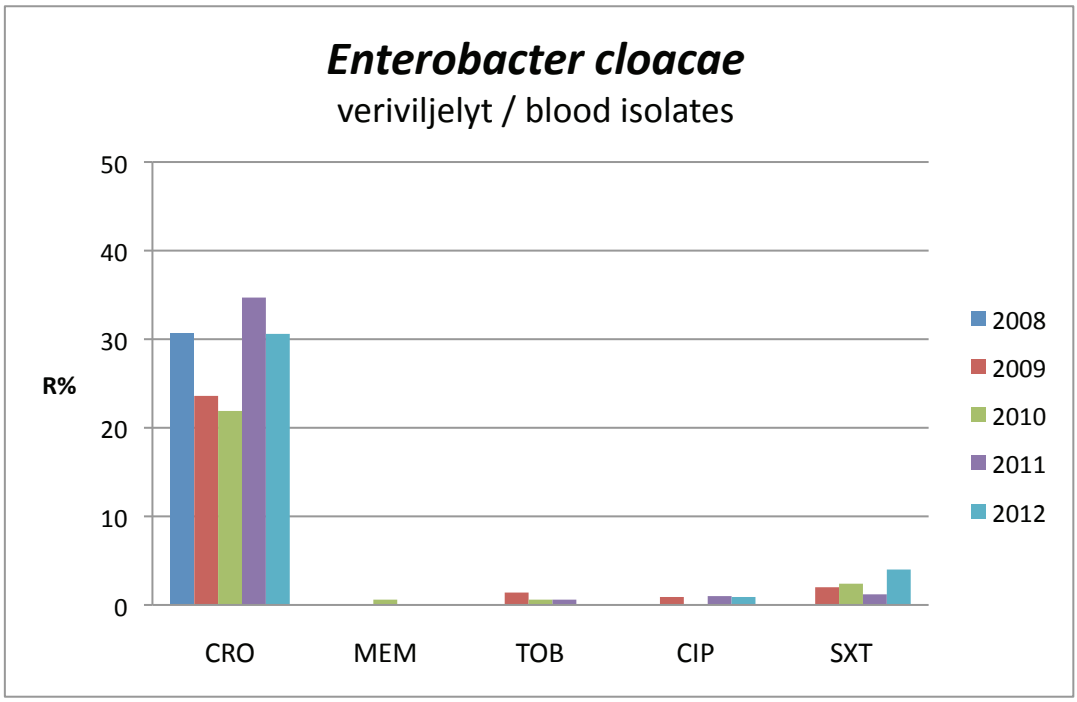

Figure 3. Antimicrobial resistance in *E. cloacae* blood isolates in 2008–2012.

Antimicrobial susceptibility of *E. cloacae* strains isolated from blood samples has remained at a high level. The increase detected in ceftriaxone resistance in 2011 is not attributable to the EUCAST transition since the clinical breakpoints have remained unchanged. As stated above, *E. cloacae* develops very easily resistance to third-generation cephalosporins. The number of strains is low, which probably explains the great variations in the proportions of resistant strains.

Table 3. Numbers and resistance percentages of *E. cloacae* blood isolates.

Antimicrobial		**2008**	**2009**	**2010**	**2011**	**2012**
Ceftriaxone	tested	101	110	146	118	147
	R%	30.7	23.6	21.9	34.7	30.6
Meropenem	tested	132	134	177	179	196
	R%	0.0	0.0	0.6	0.0	0.0
Tobramycin	tested	139	141	167	179	189
	R%	0.0	1.4	0.6	0.6	0.0
Ciprofloxacin	tested	111	110	126	104	113
	R%	0.0	0.9	0.0	1.0	0.9
Trimethoprim-sulfa	tested	143	147	166	170	199
	R%	0.0	2.0	2.4	1.2	4.0

3. *Enterococcus*

The FiRe laboratories examined 33 759 *Enterococcus* strains in 2012. A total of 23 431 strains were of the species *E. faecalis* and 4 484 of the species *E. faecium*.

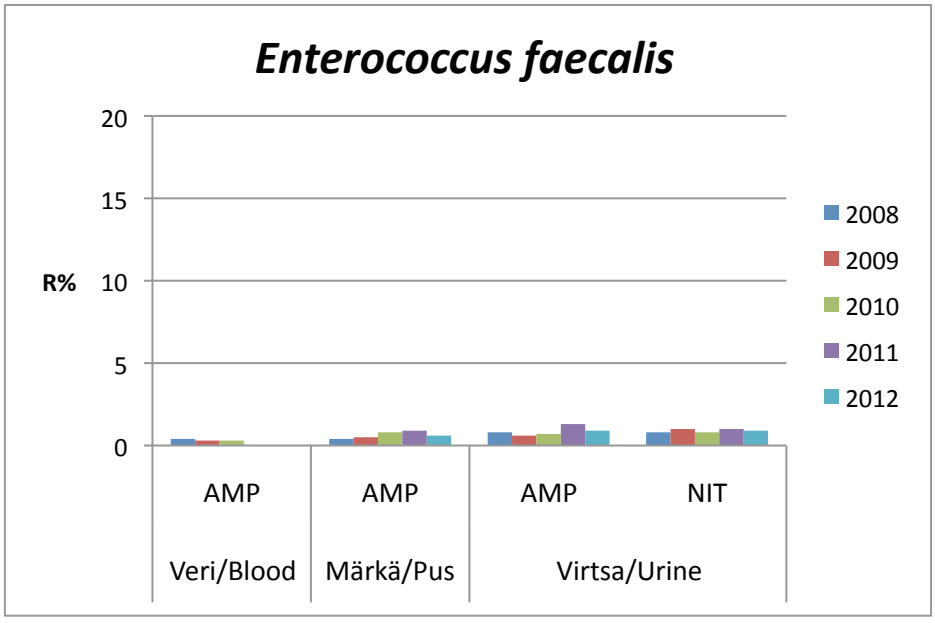

Figure 4. Antimicrobial resistance in *E. faecalis* in 2008–2012.

E. faecalis has remained very susceptible to antimicrobials that are naturally effective against it. Antimicrobial resistance is most common in *E. faecalis* urine isolates, but resistance rate to both ampicillin and nitrofurantoin has usually remained below 1%. Around 1–4 vancomycin-resistant *E. faecalis* strains (VRE) has been found annually.

Table 4. Numbers and resistance percentages of *E. faecalis* strains.

Clinical isolate	Antimicrobial		2008	2009	2010	2011	2012
Blood	**Ampicillin**	tested	262	316	323	244	324
		R%	0.4	0.3	0.3	0.0	0.0
Pus	**Ampicillin**	tested	5 031	5 516	5 434	3 499	3 723
		R%	0.4	0.5	0.8	0.9	0.6
Urine	**Ampicillin**	tested	18 554	23 109	21 653	12 975	12 874
		R%	0.8	0.6	0.7	1.3	0.9
	Nitrofurantoin	tested	21 290	23 112	21 776	14 103	16 058
		R%	0.8	1.0	0.8	1.0	0.9

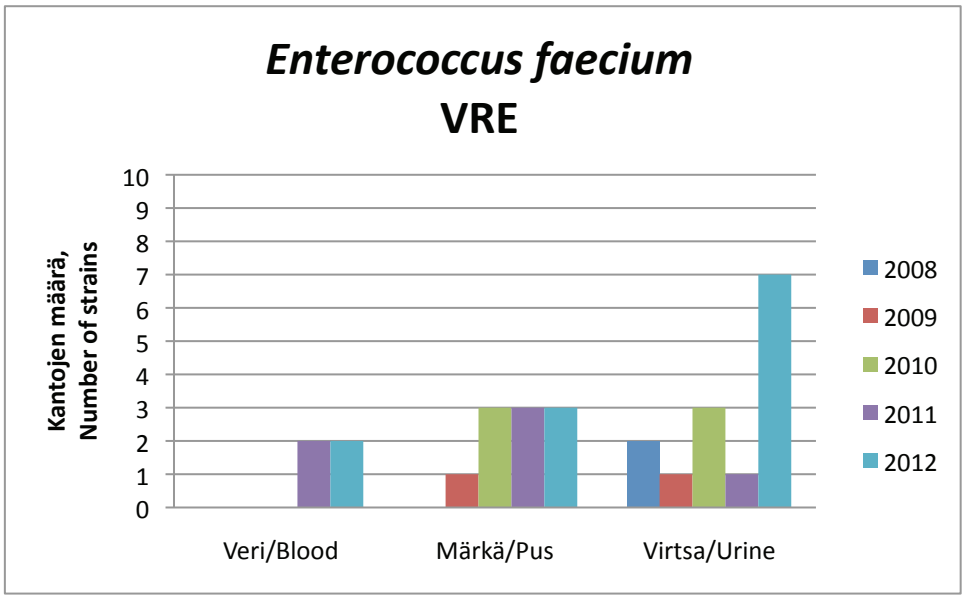

Figure 5. Numbers of vancomycin-resistant *E. faecium* strains in different clinical isolates.

The annual number of vancomycin-resistant *E. faecium* strains has been very low at 2–12 strains per year.

Table 5. Numbers of vancomycin-resistant *E. faecium* strains and the total numbers of tested strains.

Clinical isolate		2008	2009	2010	2011	2012
Blood	tested	4 592	4 755	4 057	2 832	3 096
	VRE cases	0	0	0	2	2
Pus	tested	1 654	1 451	1 431	1 111	1 253
	VRE cases	0	1	3	3	3
Urine	tested	4 592	4 755	4 057	2 832	3 096
	VRE cases	2	1	3	1	7

4. *Escherichia coli*

The FiRe laboratories examined 134 636 *Enterobacter coli* strains in 2012. Of these, 3 384 were isolated from blood samples and 122 271 from urine samples.

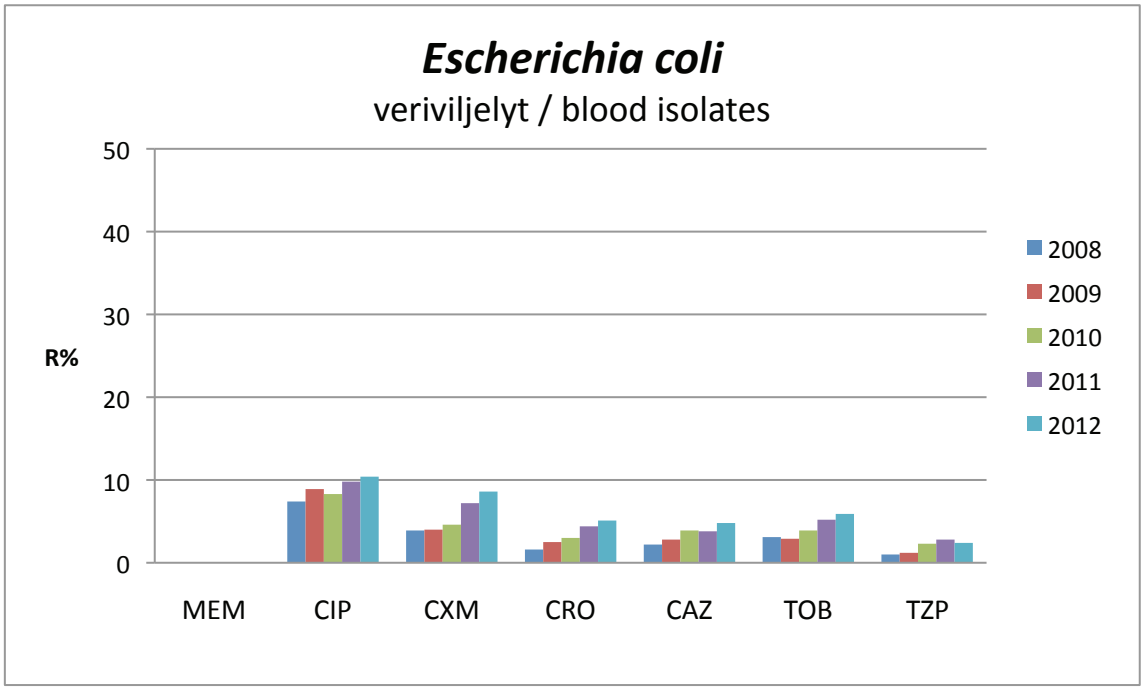

Figure 6. Antimicrobial resistance in *E. coli* blood isolates in 2008–2012.

The majority of *E. coli* blood isolates have remained susceptible to antimicrobials most commonly used in the treatment of bacteremic infections. Increasing levels of resistance has been detected against all cephalosporins, but especially against cefuroxime (Table 6). The adoption of new clinical breakpoints as part of the EUCAST transition probably explains the increase in the number of resistant isolates (the change for R: MIC ≥32 mg/l (CLSI), MIC ≥16 mg/l, (EUCAST)). Also the proportion of ESBL-producing strains is clearly on the rise (Figure 8). Some of the ESBL-producing strains are *in vitro* susceptible to piperacillin–tazobactam, which might explain the more moderate growth in the number of strains resistant to this combination of antimicrobials compared with cephalosporins. Only two carbapenem-resistant *E. coli* strains were isolated during the period under study, the first in 2008 and the second in 2010 (Table 6). Also resistance to fluoroquinolones continues to increase.

Table 6. Numbers and resistance percentages of *E. coli* blood isolates.

Antimicrobial		2008	2009	2010	2011	2012
Meropenem	tested	2 310	2 359	3 009	3 016	3 306
	R%	0.0*	0.0	0.0*	0.0	0.0
Ciprofloxacin	tested	1 944	1 848	2 048	1 828	1 973
	R%	7.4	8.9	8.3	9.8	10.4
Cefuroxime	tested	2 769	2 724	3 162	3 017	3 384
	R%	3.9	4.0	4.6	7.2	8.6
Ceftriaxone	tested	1 863	1 781	2 220	2 105	2 484
	R%	1.6	2.5	3.0	4.4	5.1
Ceftazidime	tested	2 491	2 391	2 768	2 437	3 033
	R%	2.2	2.8	3.9	3.8	4.8
Tobramycin	tested	2 584	2 518	2 948	3 017	3 214
	R%	3.1	2.9	3.9	5.2	5.9
Piperacillin–tazobactam	tested	2 766	2 651	3 030	2 383	3 221
	R%	1.0	1.2	2.3	2.8	2.4

* A meropenem-resistant strain was isolated during the year.

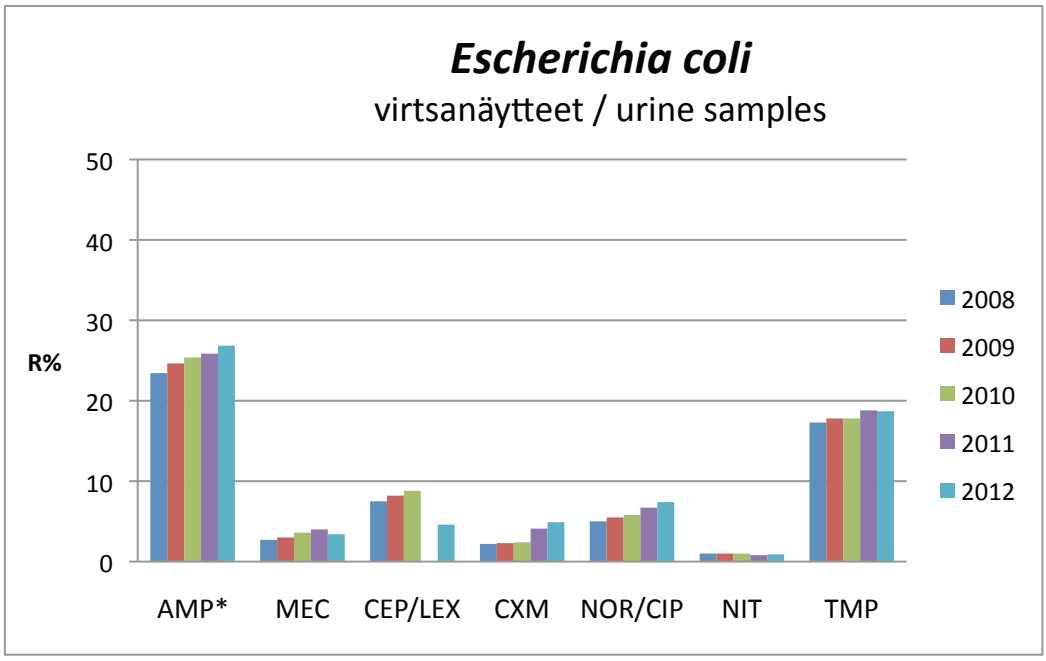

Figure 7. Antimicrobial resistance in *E. coli* urine isolates in 2008–2012 (*Ampicillin resistance is based on results from six FiRe laboratories; other laboratories have not tested susceptibility to ampicillin.)

Resistance to ampicillin and trimethoprim is fairly common in *E. coli* strains isolated from urine samples. Resistance to first-generation cephalosporins has decreased (from 7.5% in 2008 to 4.6% in 2012), although cefuroxime resistance has been increasing (from 2.2% in 2008 to 4.9% in 2012). After the adoption of the EUCAST standard, antimicrobial susceptibility are tested with cefalexin instead of cefalotine, and this probably explains the differences in the development of resistance to cephalosporins. No data were collected in 2011 because of the EUCAST transition. Resistance to nitrofurantoin and mecillinam are relatively rare in *E. coli* strains isolated from urine tract infections.

Table 7. Numbers and resistance percentages of *E. coli* urine isolates.

Antimicrobial		**2008**	**2009**	**2010**	**2011**	**2012**
Ampicillin	tested	9 336	27 879	27 027	26 780	26 011
	R%	23.4	24.6	25.4	25.9	26.9
Mecillinam	tested	115 566	118 735	112 337	107 160	117 217
	R%	2.7	3.0	3.6	4.0	3.4
Cefalothin/cefalexin	tested	88 615	92 532	91 871	51 496	76 306
	R%	7.5	8.2	8.8	-	4.6
Cefuroxime	tested	98 250	112 775	114 889	106 479	113 820
	R%	2.2	2.3	2.4	4.1	4.9
Norfloxacin/ciprofloxacin	tested	76 405	77 707	77 383	65 582	82 478
	R%	5.0	5.5	5.8	6.7	7.4
Nitrofurantoin	tested	118 019	123 323	115 471	89 663	108 411
	R%	1.0	1.0	1.0	0.8	0.9
Trimethoprim	tested	117 991	123 313	118 132	112 176	122 229
	R%	17.3	17.8	17.8	18.8	18.7

The FiRe laboratories screen for ESBL production in *E. coli* strains resistant to third-generation cephalosporins and report the results into the Finres database.

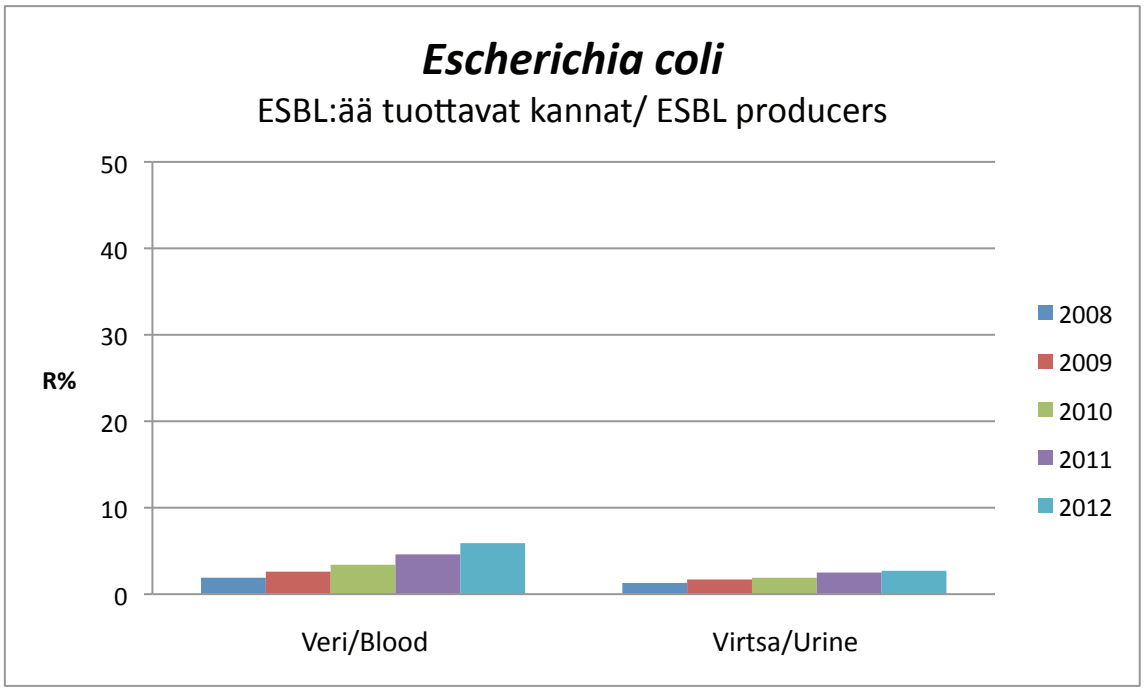

Figure 8. Proportion of ESBL-producing *E. coli* strains in different clinical isolates in 2008–2012.

The proportion of ESBL producers in all *E. coli* blood isolates has increased steadily, reaching 5.9% in 2012. In *E. coli* urine isolates, the growth of ESBL producers has been more moderate, reaching 2.7% in 2012.

Table 8. Numbers and ESBL percentages of *E. coli* strains.

Clinical isolate		2008	2009	2010	2011	2012
Veri/Blood	tested	2 770	2 724	3 164	3 017	3 384
	ESBL%	1.9	2.6	3.4	4.6	5.9
Virtsa/Urine	tested	118 221	125 187	121 788	112 588	122 271
	ESBL%	1.3	1.7	1.9	2.5	2.7

5. *Haemophilus influenzae*

In 2012, the FiRe laboratories examined 4 127 *Haemophilus influenzae* strains, 1 467 of which were collected from children under 5 years of age. A total of 3 622 strains were isolated from pus samples.

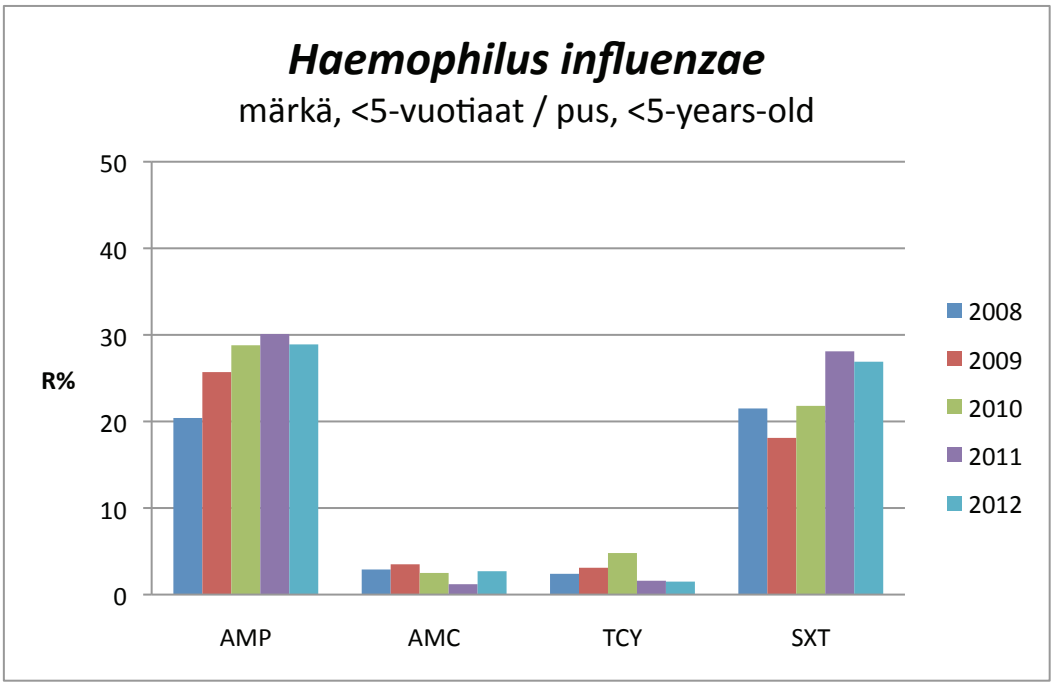

Figure 9. Antimicrobial resistance in *H. influenzae* pus isolates collected from children aged under 5 in 2008–2012.

H. influenzae strains isolated from children aged under 5 have a fairly high level of resistance against ampicillin and trimethoprim-sulfa. Resistance to amoxicillin–clavulanate has remained low (at 1.2–3.5%) during the past five years. The same applies to tetracycline resistance.

Table 9. Numbers and resistance percentages of *H. influenzae* pus isolates collected from children aged under 5.

Antimicrobial		**2008**	**2009**	**2010**	**2011**	**2012**
Ampicillin	tested	1 384	1 228	1 801	1 375	1 165
	R%	20.4	25.7	28.8	30.1	28.9
Amoxicillin-clavulanate	tested	1 465	1 191	1 252	1 770	1 376
	R%	2.9	3.5	2.5	1.2	2.7
Tetracycline	tested	1 160	880	1 186	1 264	1 021
	R%	2.4	3.1	4.8	1.6	1.5
Trimethoprim-sulfa	tested	1 524	1 186	1 737	1 774	1 434
	R%	21.5	18.1	21.8	28.1	26.9

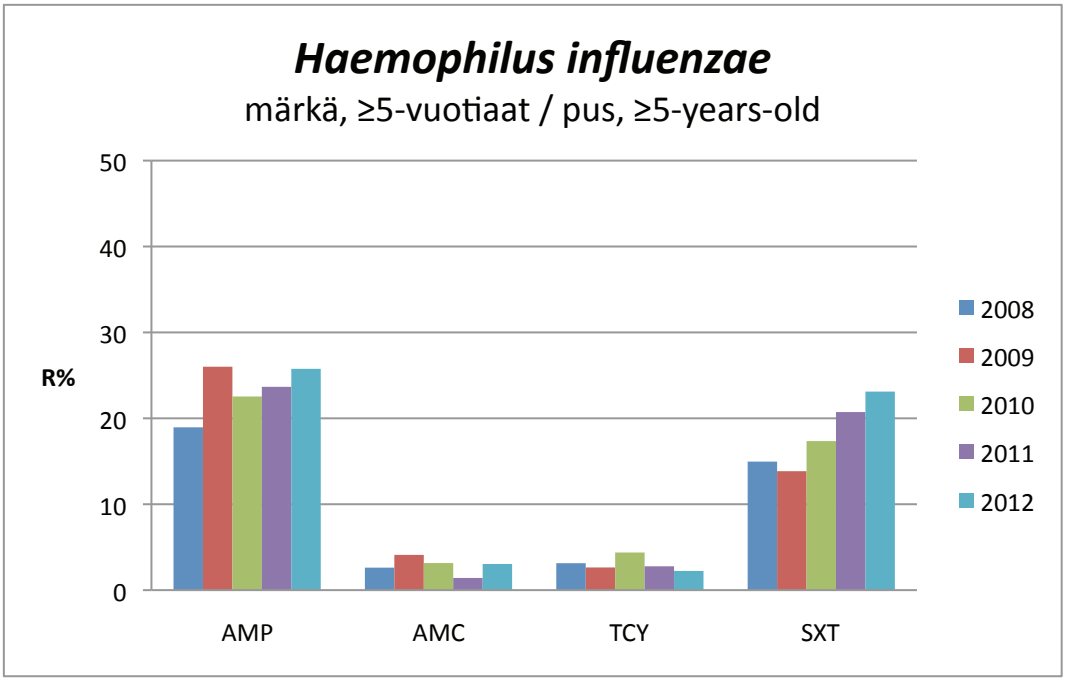

Figure 10. Antimicrobial resistance in *H. influenzae* pus isolates collected from patients aged 5 years and over in 2008–2012.

Resistance to ampicillin and trimethoprim-sulfa seems to be increasing steadily in *H. influenzae* strains isolated from patients aged 5 years and over, while resistance to amoxicillin–clavulanate and tetracycline has remained low.

Table 10. Numbers and resistance percentages of *H. influenzae* pus isolates collected from patients aged 5 years and over.

Antimicrobial		**2008**	**2009**	**2010**	**2011**	**2012**
Ampicillin	tested	1 641	1 838	2 258	1 724	1 708
	R%	19.0	26.0	22.5	23.7	25.8
Amoxicillin-clavulanate	tested	1 795	1 780	1 745	2 185	2 036
	R%	2.6	4.1	3.2	1.4	3.0
Tetracycline	tested	1 467	1 402	1 644	1 766	1 747
	R%	3.1	2.6	4.4	2.8	2.2
Trimethoprim-sulfa	tested	1 878	1 820	2 242	2 195	2 172
	R%	15.0	13.8	17.4	20.7	23.1

6. *Klebsiella oxytoca*

The FiRe laboratories examined 4 901 *Klebsiella oxytoca* strains in 2012. Of these, 160 were isolated from blood samples and 3 574 from urine samples.

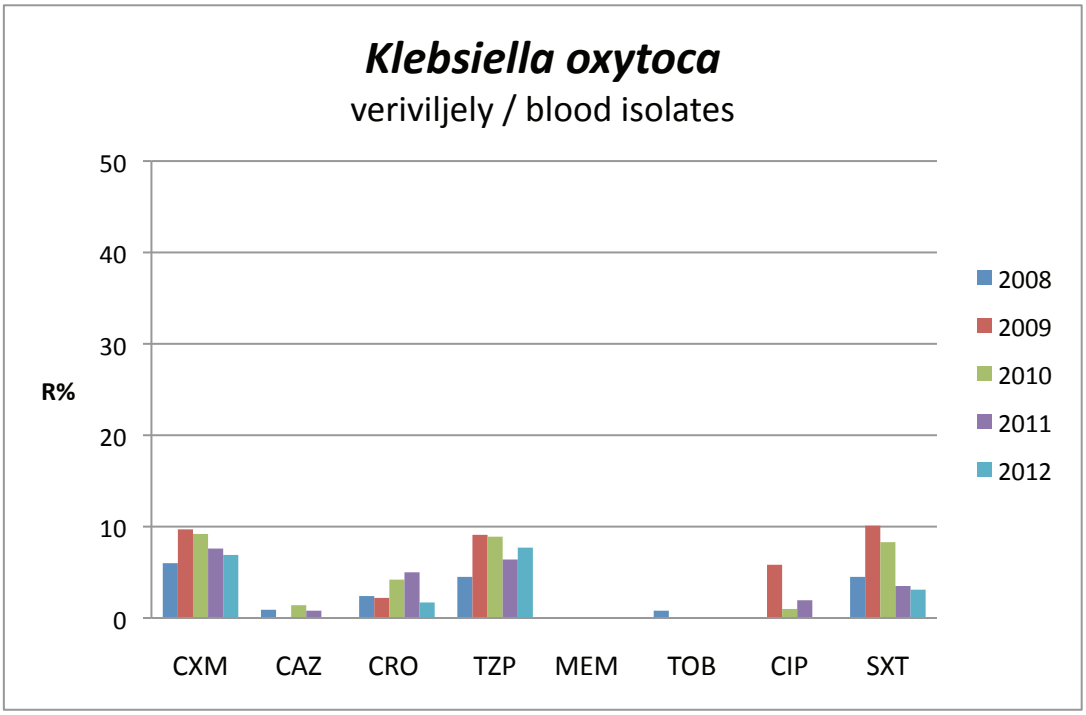

Figure 11. Antimicrobial resistance in *K. oxytoca* blood isolates in 2008–2012.

Acquired antimicrobial resistance in *K. oxytoca* strains is fairly rare. As the natural beta-lactamase of *K. oxytoca* inactivates to some extent second- and third-generation cephalosporins, this species has a higher level of resistance to these antimicrobials than *K. pneumoniae*. It should be taken into account, however, that the great fluctuations in the resistance percentages are only apparent and can be explained by small number of tested strains. All tested isolates have been susceptible to meropenem.

Table 11. Numbers and resistance percentages of *K. oxytoca* blood isolates.

Antimicrobial		2008	2009	2010	2011	2012
Cefuroxime	tested	134	155	163	158	160
	R%	6.0	9.7	9.2	7.6	6.9
Ceftazidime	tested	108	136	142	125	141
	R%	0.9	0.0	1.4	0.8	0.0
Ceftriaxone	tested	82	93	120	119	119
	R%	2.4	2.2	4.2	5.0	1.7
Piperacillin–tazobactam	tested	134	154	157	125	155
	R%	4.5	9.1	8.9	6.4	7.7
Meropenem	tested	112	132	156	158	155
	R%	0.0	0.0	0.0	0.0	0.0
Tobramycin	tested	124	145	151	158	155
	R%	0.8	0.0	0.0	0.0	0.0
Ciprofloxacin	tested	95	103	101	103	95
	R%	0.0	5.8	1.0	1.9	0.0
Trimethoprim-sulfa	tested	133	149	144	142	160
	R%	4.5	10.1	8.3	3.5	3.1

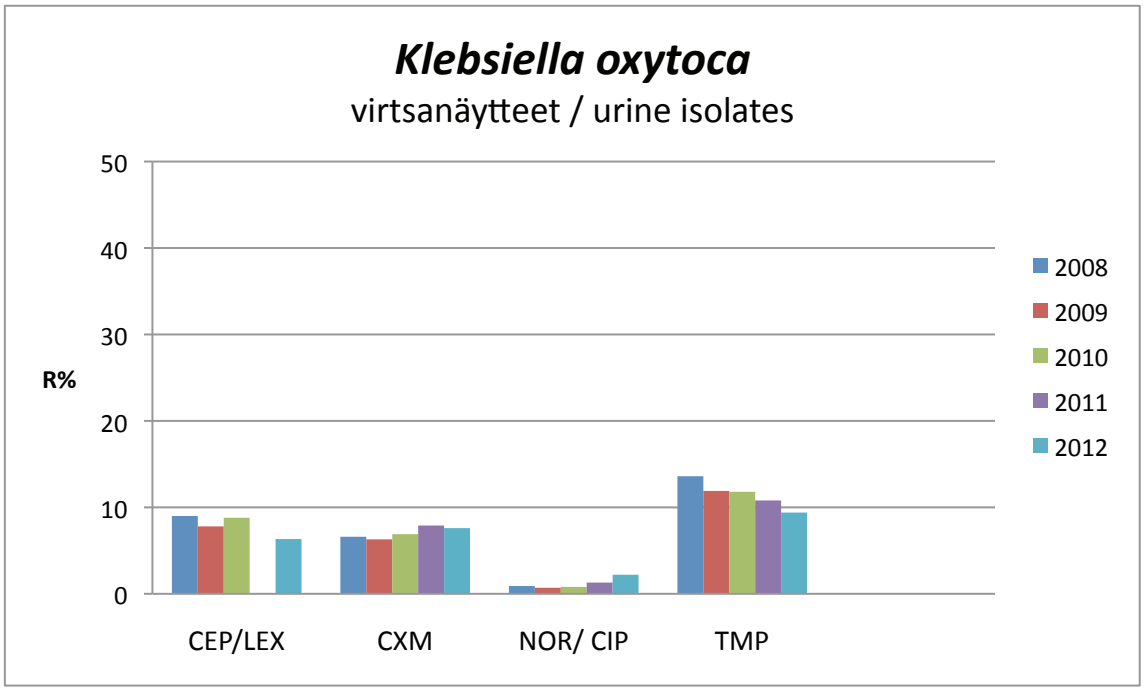

Figure 12. Antimicrobial resistance in *K. oxytoca* urine isolates in 2008–2012.

As stated above, the declining trend expressed in Figure 12 concerning resistance to first-generation cephalosporins is probably the result of switching from cefalothin to cefalexin as the tested antimicrobial agent. No similar decrease in the resistance percentages can be detected for cefuroxime, while trimethoprim resistance has clearly decreased over the years.

Table 12. Numbers and resistance percentages of *K. oxytoca* urine isolates.

Antimicrobial		2008	2009	2010	2011	2012
Cefalothin/cefalexin	tested	2 995	3 176	2 843	1 416	2 099
	R%	9.0	7.8	8.8	-	6.3
Cefuroxime	tested	3 373	3 936	3 671	3 367	3 573
	R%	6.6	6.3	6.9	7.9	7.6
Norfloxacin/ciprofloxacin	tested	2 223	2 471	2 197	1 880	2 311
	R%	0.9	0.7	0.8	1.3	2.2
Trimethoprim	tested	3 787	4 010	3 594	3 360	3 573
	R%	13.6	11.9	11.8	10.8	9.4

7. *Klebsiella pneumonia*

The FiRe laboratories examined 15 183 *Klebsiella pneumoniae* strains in 2012. Most of these, altogether 13 381 strains, were isolated from urine samples, while 569 were isolated from blood samples.

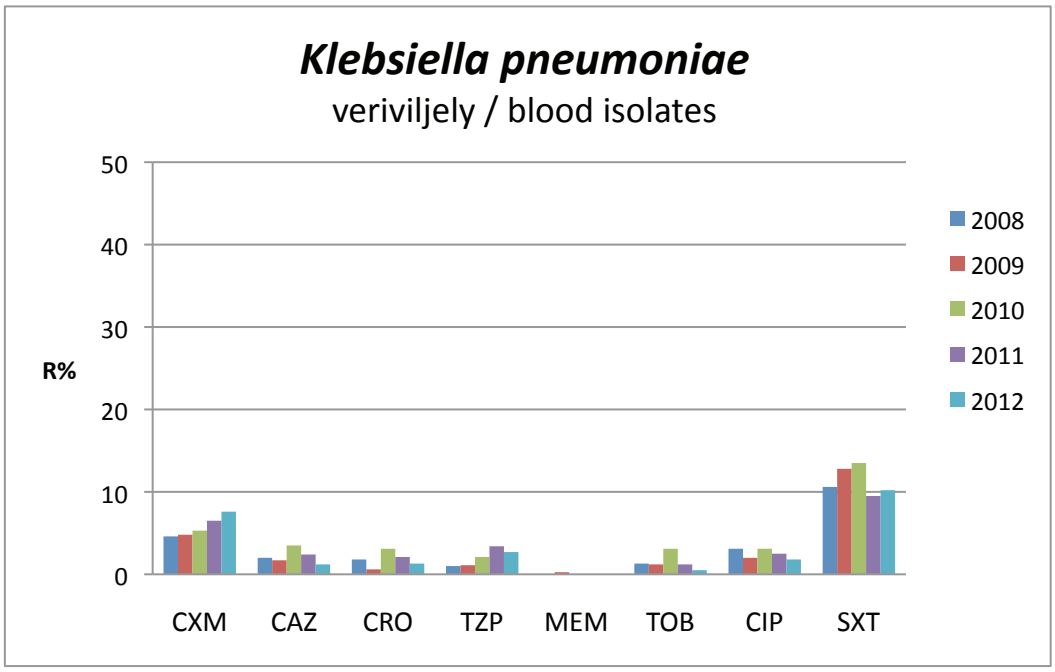

Figure 13. Antimicrobial resistance in *K. pneumoniae* blood isolates in 2008–2012.

Antimicrobial susceptibility of *K. pneumoniae* strains isolated from blood samples has remained at a high level. Only cefuroxime resistance shows some increase (from 4.6% in 2008 to 7.6% in 2012), which is probably due to the same factors as for *E. coli* explained above. The number of *K. pneumoniae* blood isolates is, however, low, which explains the great variations in the resistance percentages. So far, only one meropenem-resistant *K. pneumoniae* strain has been isolated from blood. This happened in 2009 (Table 13).

Table 13. Numbers and resistance percentages of *K. pneumoniae* blood isolates.

Antimicrobial		2008	2009	2010	2011	2012
Cefuroxime	tested	414	461	488	402	569
	R%	4.6	4.8	5.3	6.5	7.6
Ceftazidime	tested	358	403	431	329	520
	R%	2.0	1.7	3.5	2.4	1.2
Ceftriaxone	tested	271	310	355	284	395
	R%	1.8	0.6	3.1	2.1	1.3
Piperacillin–tazobactam	tested	414	446	473	324	550
	R%	1.0	1.1	2.1	3.4	2.7
Meropenem	tested	339	392	461	402	557
	R%	0.0	0.3*	0.0	0.0	0.0
Tobramycin	tested	391	431	454	402	549
	R%	1.3	1.2	3.1	1.2	0.5
Ciprofloxacin	tested	295	303	322	244	331
	R%	3.1	2.0	3.1	2.5	1.8
Trimethoprim-sulfa	tested	405	452	416	379	569
	R%	10.6	12.8	13.5	9.5	10.2

* A meropenem-resistant strain was isolated during the year.

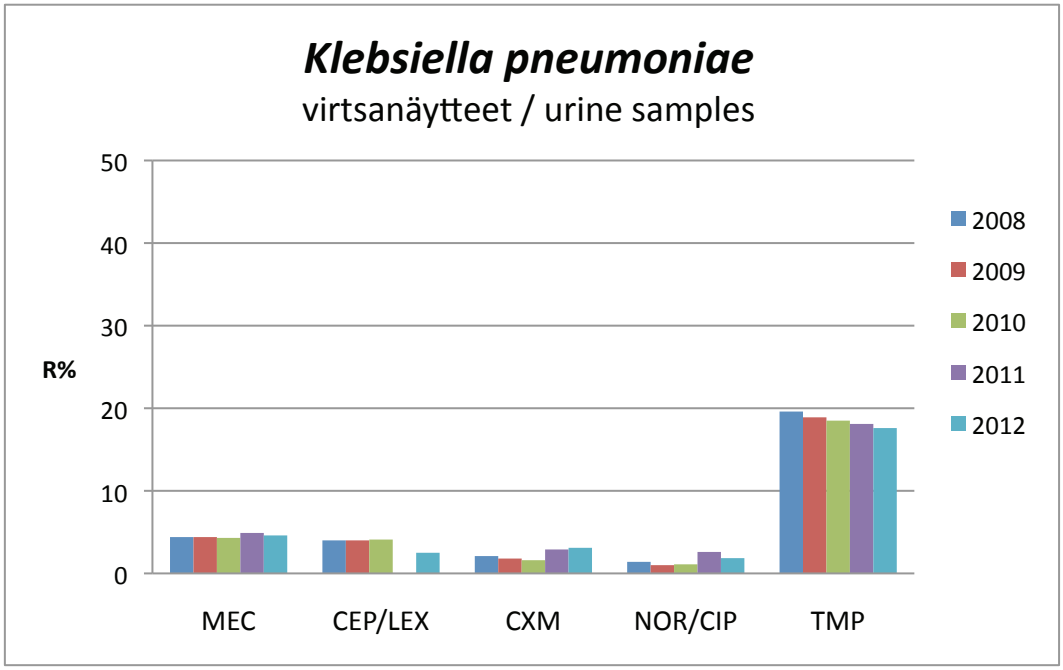

Figure 14. Antimicrobial resistance in *K. pneumoniae* urine isolates in 2008–2012.

Antimicrobial resistance in *K. pneumoniae* urine isolates has remained stable and at a low level. Only trimethoprim resistance is more common, although slightly declining. As a result of the EUCAST transition, laboratories now test susceptibility against cefalexin instead of cefalothine (cf. *E. coli*). The EUCAST clinical breakpoints for nitrofurantoin are not applicable for the *Klebsiella* spp.

Table 14. Numbers and resistance percentages of *K. pneumoniae* urine isolates.

Antimicrobial		2008	2009	2010	2011	2012
Mecillinam	tested	12 155	11 440	10 821	10 328	11 175
	R%	4.4	4.4	4.3	4.9	4.6
Cefalothin/cefalexin	tested	10 348	10 521	10 163	5 274	7 818
	R%	4.0	4.0	4.1	-	2.5
Cefuroxime	tested	11 201	12 773	12 645	12 370	13 377
	R%	2.1	1.8	1.6	2.9	3.1
Norfloxacin/ciprofloxacin	tested	8 273	8 385	8 019	7 096	8 488
	R%	1.4	1.0	1.1	2.6	1.8
Trimethoprim	tested	12 997	13 318	12 433	12 346	13 379
	R%	19.6	18.9	18.5	18.1	17.6

The FiRe laboratories screen for ESBL production in *K. pneumoniae* strains resistant to third-generation cephalosporins and report the results into the Finres database.

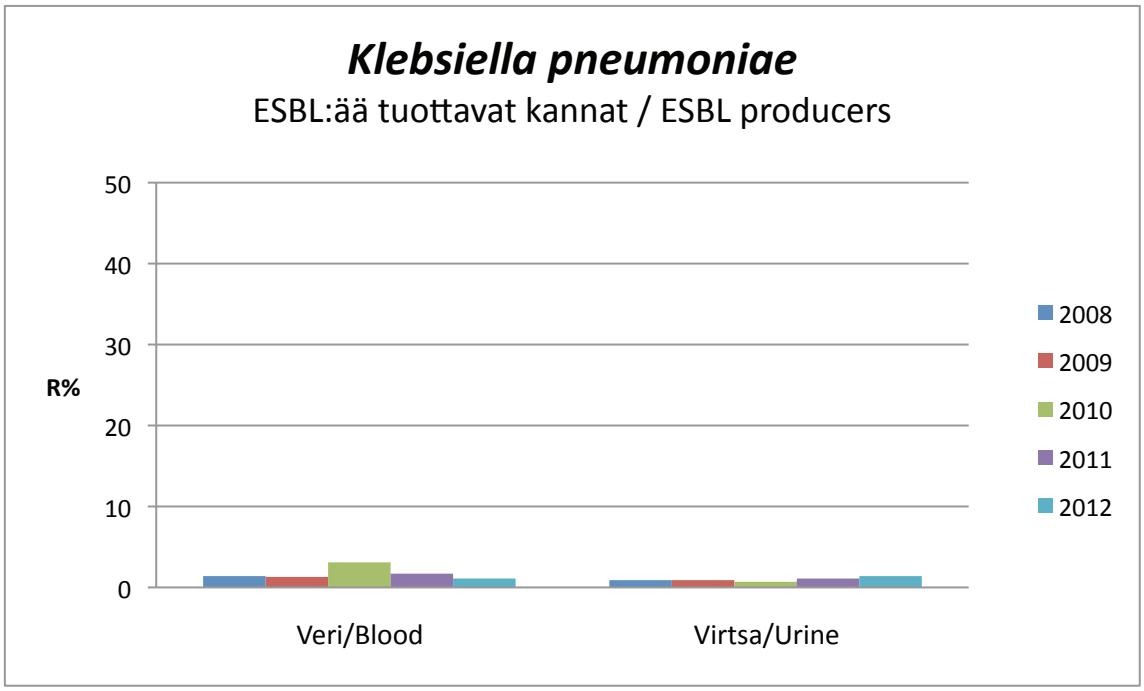

Figure 15. Proportion of ESBL-producing *K. pneumoniae* strains in different clinical isolates in 2008–2012.

The number of ESBL-producing *K. pneumoniae* strains has remained low. ESBL-producers accounted for 1.4% of all *K. pneumoniae* urine isolates in 2012. The ESBL percentage of blood isolates seems to be decreasing (from 3.1% to 1.1%), although the low number of isolates means that even small variations are reflected as significant changes in percentage values. For example, the growth in 2010 is the result of 15 ESBL-producing strains, while there were only 7 strains in 2011 and 6 in 2012.

Table 15. Numbers and ESBL percentages of *K. pneumoniae* blood and urine isolates.

Clinical isolate		2008	2009	2010	2011	2012
Veri/Blood	tested	414	461	488	402	569
	ESBL%	1.4	1.3	3.1	1.7	1.1
Virtsa/Urine	tested	13 027	13 552	12 695	12 375	13 381
	ESBL%	0.9	0.9	0.7	1.1	1.4

8. *Moraxella catarrhalis*

In 2012, the FiRe laboratories examined 1 849 *Moraxella catarrhalis* strains, of which 1 779 were isolated from pus samples. Over a half of these (1 005) were isolated from samples collected from children aged under 5.

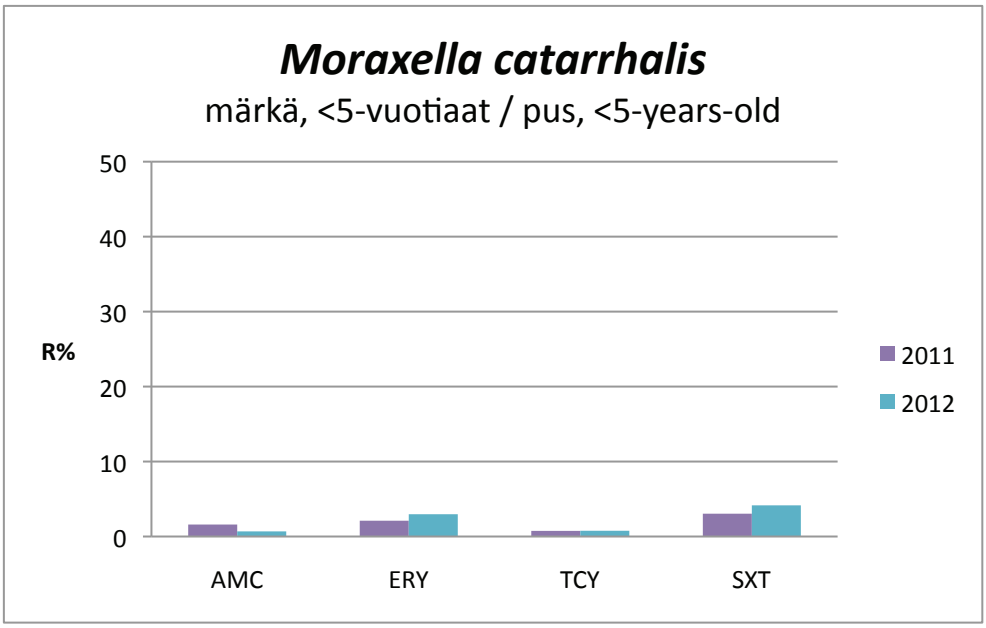

Figure 16. Antimicrobial resistance in *M. catarrhalis* pus isolates collected from children aged under 5 in 2011–2012.

Most *M. catarrhalis* pus isolates collected from children aged under 5 are still susceptible to erythromycin, tetracycline, trimethoprim-sulfa, and amoxicillin–clavulanate.

Table 16. Numbers and resistance percentages of *M. catarrhalis* pus isolates collected from children aged under 5.

Antimicrobial		**2011**	**2012**
Amoxicillin-clavulanate	tested	1 001	877
	R%	1.6	0.7
Erythromycin	tested	664	639
	R%	2.1	3.0
Tetracycline	tested	665	651
	R%	0.8	0.8
Trimethoprim-sulfa	tested	1 051	986
	R%	3.0	4.2

9. *Neisseria gonorrhoeae*

The FiRe laboratories examined 146 *Neisseria gonorrhoeae* strains in 2012.

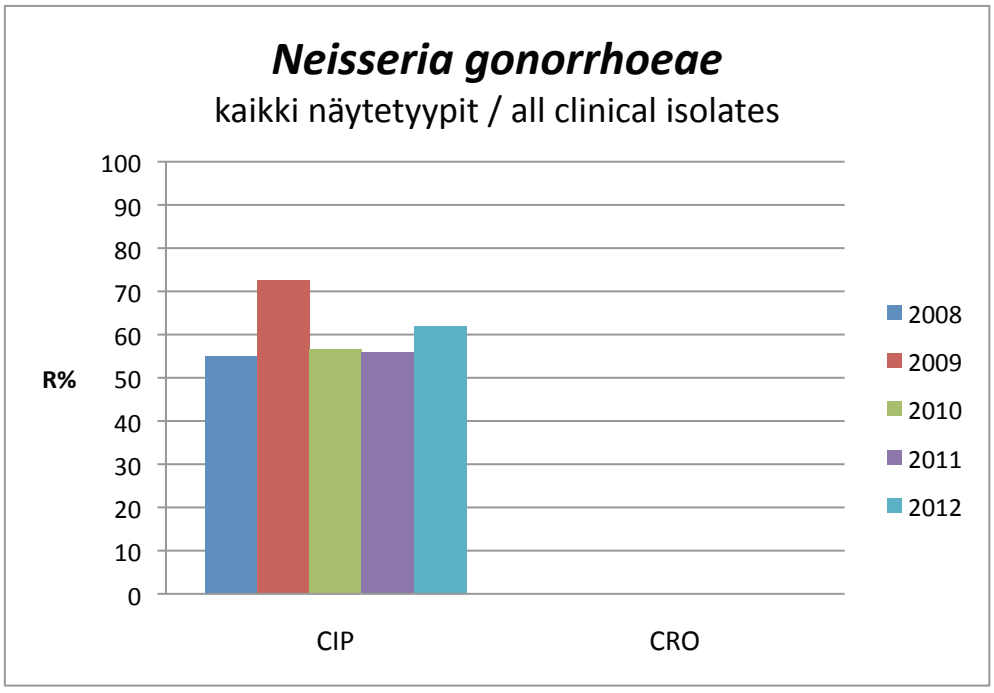

Figure 17. Antimicrobial resistance in *N. gonorrhoeae* in 2008–2012.

More than half of the tested *N. gonorrhoeae* strains were resistant to ciprofloxacin (Table 17), while no ceftriaxone-resistant strains have so far been detected in Finland.

Table 17. Numbers and resistance percentages of *N. gonorrhoeae* strains.

Antimicrobial		**2008**	**2009**	**2010**	**2011**	**2012**
Ciprofloxacin	tested	91	124	122	143	144
	R%	54.9	72.6	56.6	55.9	61.8
Ceftriaxone	tested	90	123	121	144	146
	R%	0.0	0.0	0.0	0.0	0.0

10. *Pseudomonas aeruginosa*

FiRe laboratories examined 12 755 *Pseudomonas aeruginosa* strains in 2012. Of these, 340 were isolated from blood samples.

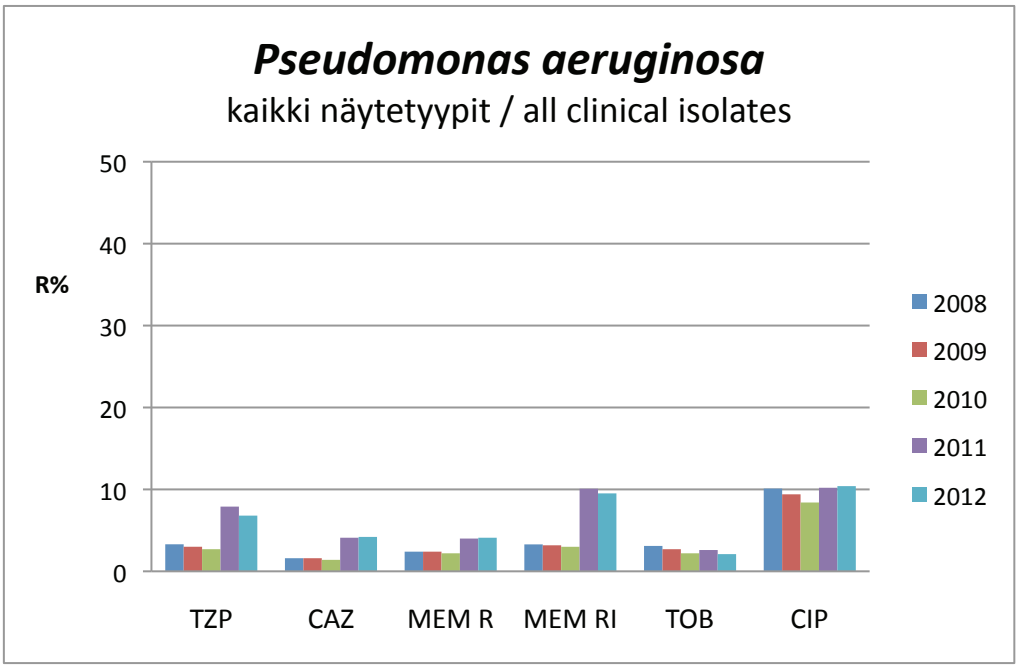

Figure 18. Antimicrobial resistance in *P. aeruginosa* in 2008–2012.

P. aeruginosa strains have remained relatively susceptible to ceftazidime, meropenem, and tobramycin. The growth in resistance to piperacillin–tazobactam and ceftazidime (in 2011) is largely due to the EUCAST transition. The previously used CLSI clinical breakpoints were able to detect only some strains resistant to piperacillin–tazobactam or ceftazidime. For *P. aeruginosa* the change in clinical breakpoints was particularly significant: for example, for piperacillin–tazobactam the CLSI breakpoint for resistance was MIC ≥ 64/4 mg/l, while the EUCAST R breakpoint is MIC > 16/4 mg/l. A particularly great change can be observed in strains non-susceptible (RI) to meropenem. This is at least partly a result of the change in the clinical breakpoints after the EUCAST transfer (meropenem breakpoint for susceptibility was changed from MIC ≤ 4 mg/l (CLSI) to MIC ≤ 2 mg/l (EUCAST)). However, also the proportion of resistant strains has increased, even though there has been no change in the R breakpoint. The development of carbapenem-resistant *P. aeruginosa* strains should be monitored.

Table 18. Numbers and resistance percentages of *P. aeruginosa* strains.

Antimicrobial		**2008**	**2009**	**2010**	**2011**	**2012**
Piperacillin–tazobactam	tested	13 539	13 455	13 848	10 202	12 612
	R%	3.3	3	2.7	7.9	6.8
Ceftazidime	tested	13 545	13 870	14 452	10 720	12 355
	R%	1.6	1.6	1.4	4.1	4.2
Meropenem	tested	11 861	12 247	12 853	12 644	12 234
	R%	2.4	2.4	2.2	4	4.1
	RI%	3.3	3.2	3.0	10.1	9.5
Tobramycin	tested	13 081	13 315	13 963	13 322	12 743
	R%	3.1	2.7	2.2	2.6	2.1
Ciprofloxacin	tested	12 957	13 216	13 900	12 306	11 324
	R%	10.1	9.4	8.4	10.2	10.4

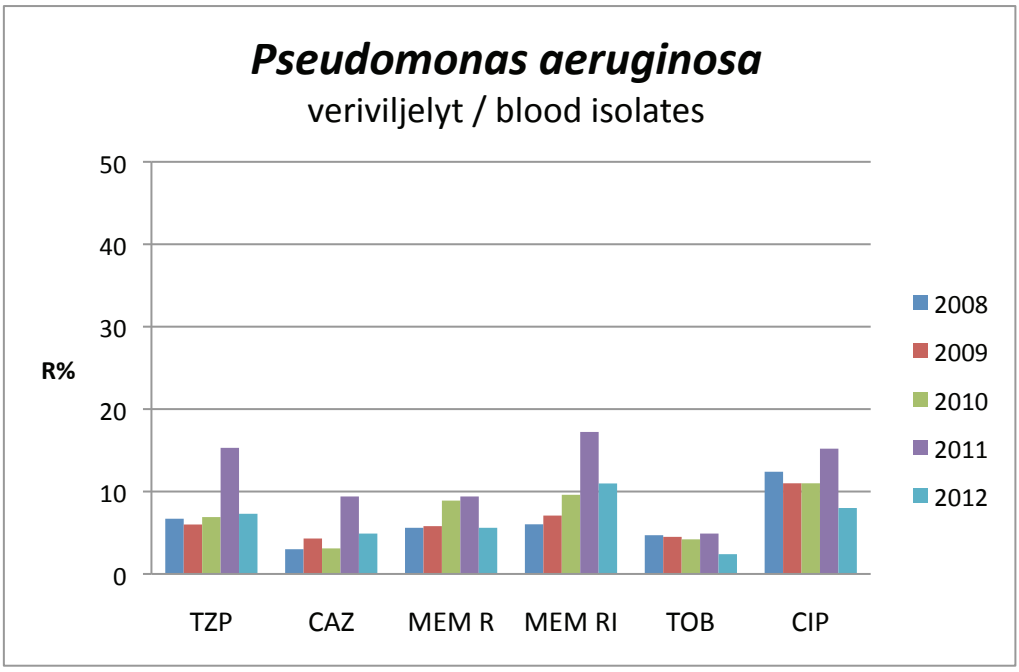

Figure 19. Antimicrobial resistance in *P. aeruginosa* blood isolates in 2008–2012.

Antimicrobial resistance is more common in *P. aeruginosa* blood isolates than in other types of *P. aeruginosa* isolates. It is, however, likely that the great fluctuations in the resistance percentages of *P. aeruginosa* blood isolates are random and can be explained by the small number of tested strains. As mentioned before, changes in the resistance to certain antimicrobial agents are affected by changes in clinical breakpoints as a result of the 2011 EUCAST transition.

Table 19. Numbers and resistance percentages of *P. aeruginosa* blood isolates.

Antimicrobial		2008	2009	2010	2011	2012
Piperacillin–tazobactam	tested	267	251	305	209	327
	R%	6.7	6.0	6.9	15.3	7.3
Ceftazidime	tested	268	255	319	213	326
	R%	3.0	4.3	3.1	9.4	4.9
Meropenem	tested	249	240	302	267	337
	R%	5.6	5.8	8.9	9.4	5.6
	RI%	6.0	7.1	9.6	17.2	11.0
Tobramycin	tested	258	246	308	267	339
	R%	4.7	4.5	4.2	4.9	2.4
Ciprofloxacin	tested	267	255	318	231	326
	R%	12.4	11.0	11.0	15.2	8.0

11. *Serratia marcescens*

The FiRe laboratories examined 1 450 *Serratia marcescens* strains in 2012. Of these, 959 were isolated from pus samples and 457 from urine samples.

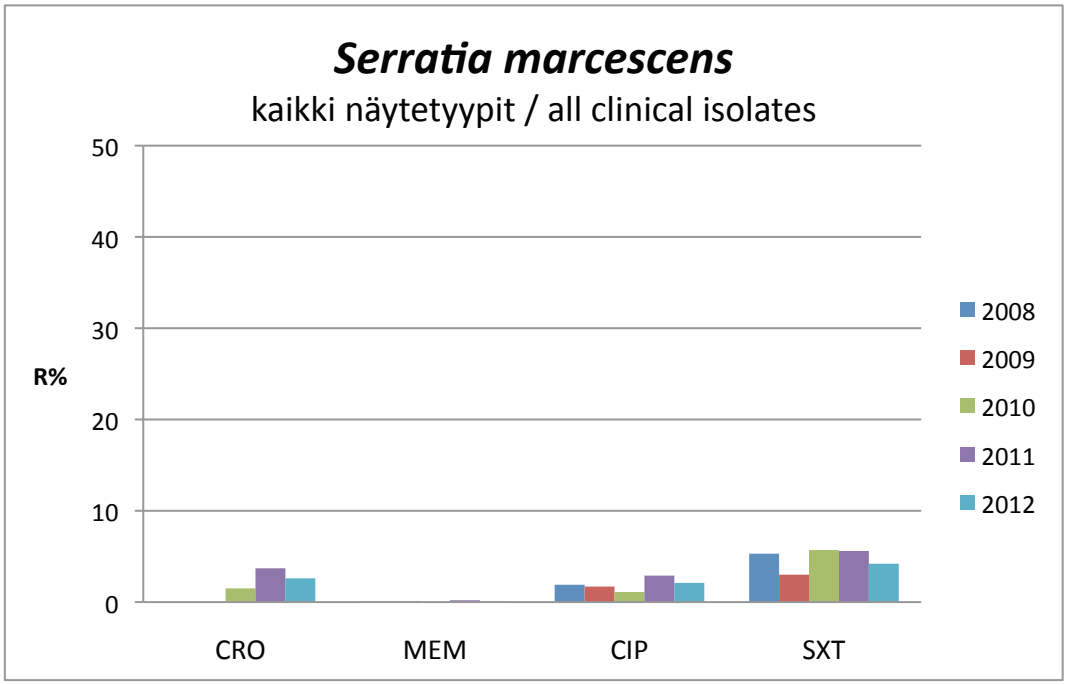

Figure 20. Antimicrobial resistance in *S. marcescens* in 2008–2012.

The number of meropenem-resistant *S. marcescens* strains is very low in the Finres data. Only 0–2 meropenem-resistant strains have been found annually.

Table 20. Numbers and resistance percentages of *S. marcescens*strains.

Antimicrobial		**2008**	**2009**	**2010**	**2011**	**2012**
Ceftriaxone	tested	488	540	711	758	847
	R%	-	-	1.5	3.7	2.6
Meropenem	tested	699	753	949	1 128	1 238
	R%	0.1	0.1	0.0	0.2	0.1
Ciprofloxacin	tested	740	783	811	852	900
	R%	1.9	1.7	1.1	2.9	2.1
Trimethoprim-sulfa	tested	981	999	1 047	1 095	1 330
	R%	5.3	3.0	5.7	5.6	4.2

12. *Staphylococcus aureus*

The FiRe laboratories examined 35 997 *Staphylococcus aureus* strains in 2012. Of these, 32 935 were isolated from pus samples and 1 510 from blood samples.

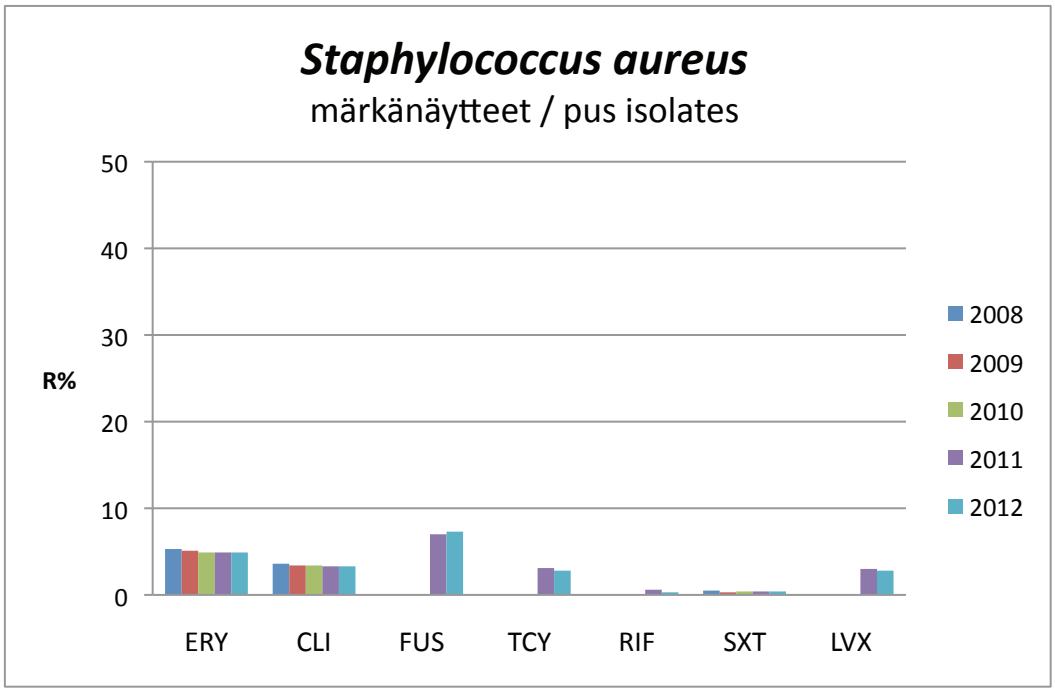

Figure 21. Antimicrobial resistance in *S. aureus* pus isolates in 2008–2012.

The susceptibility of *S. aureus* to the antimicrobials in use has remained at a high level. Resistance to erythromycin and clindamycin has even decreased a little. No data on resistance to fusidic acid, tetracyline, rifampicin and levofloxacin are available for 2008–2010, because the laboratories tested only less than 50% of all the *S. aureus* pus isolates.

Table 21. Numbers and resistance percentages of *S. aureus* pus isolates.

Antimicrobial		2008	2009	2010	2011	2012
Erythromycin	tested	31 914	31 763	32 946	31 595	32 595
	R%	5.3	5.1	4.9	4.9	4.9
Clindamycin	tested	31 837	31 561	32 774	31 612	32 842
	R%	3.6	3.4	3.4	3.3	3.3
Fusidic acid	tested	12	756	1 121	16 280	17 386
	R%	-	-	-	7.0	7.3
Tetracycline	tested	14 527	14 430	12 248	19 510	20 908
	R%	-	-	-	3.1	2.8
Rifampicin	tested	12 419	13 506	13 918	16 639	17 590
	R%	-	-	-	0.6	0.3
Trimethoprim-sulfa	tested	20 767	20 886	21 362	21 586	23 750
	R%	0.5	0.3	0.4	0.4	0.4
Levofloxacin	tested	0	0	0	18 506	22 175
	R%	-	-	-	3.0	2.8

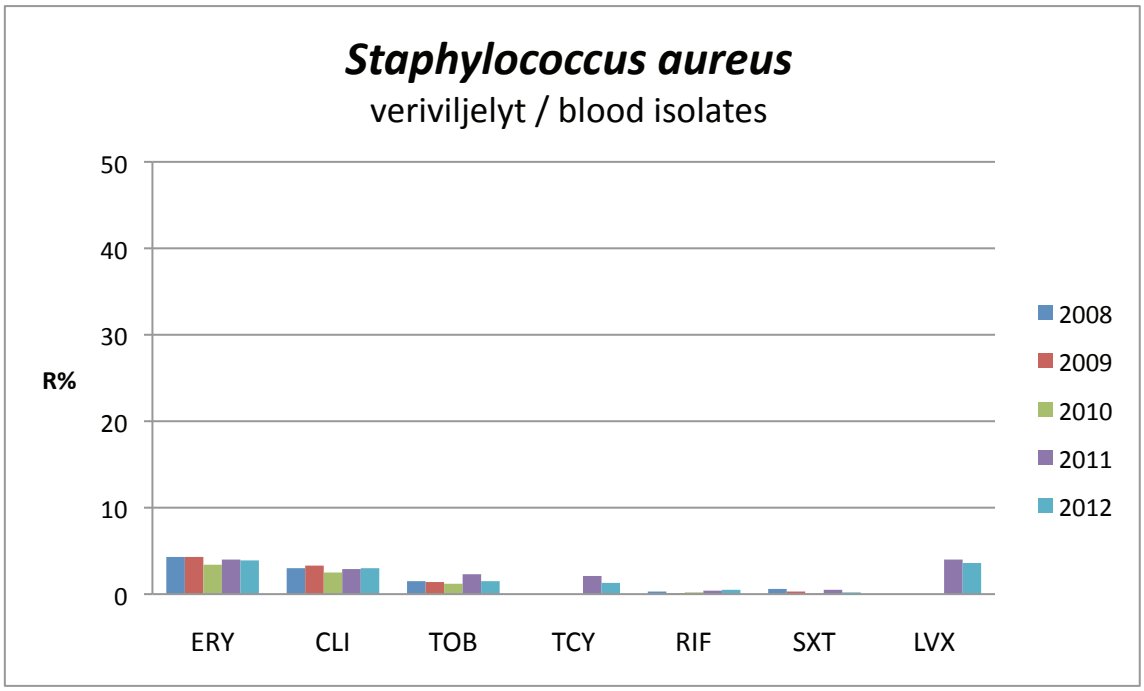

Figure 22. Antimicrobial resistance in *S. aureus* blood isolates in 2008–2012.

Also the susceptibility of *S. aureus* blood isolates has remained good.

Table 22. Numbers and resistance percentages of *S. aureus* blood isolates.

Antimicrobial		2008	2009	2010	2011	2012
Erythromycin	tested	1 248	1 245	1 386	1 314	1 506
	R%	4.3	4.3	3.4	4.0	3.9
Clindamycin	tested	1 248	1 245	1 387	1 314	1 510
	R%	3.0	3.3	2.5	2.9	3.0
Tobramycin	tested	939	921	738	736	975
	R%	1.5	1.4	1.2	2.3	1.5
Tetracycline	tested	377	312	426	872	971
	R%	-	-	-	2.1	1.3
Rifampicin	tested	1 205	1 201	1 314	1 199	1 472
	R%	0.3	0.1	0.2	0.4	0.5
Trimethoprim-sulfa	tested	1 050	1 026	1 202	1 172	1 415
	R%	0.6	0.3	0.1	0.5	0.2
Levofloxacin	tested	0	0	0	988	1 178
	R%	-	-	-	4.0	3.6

In 2012, the FiRe laboratories tested 35 997 *Staphylococcus aureus* strains for methicillin resistance.

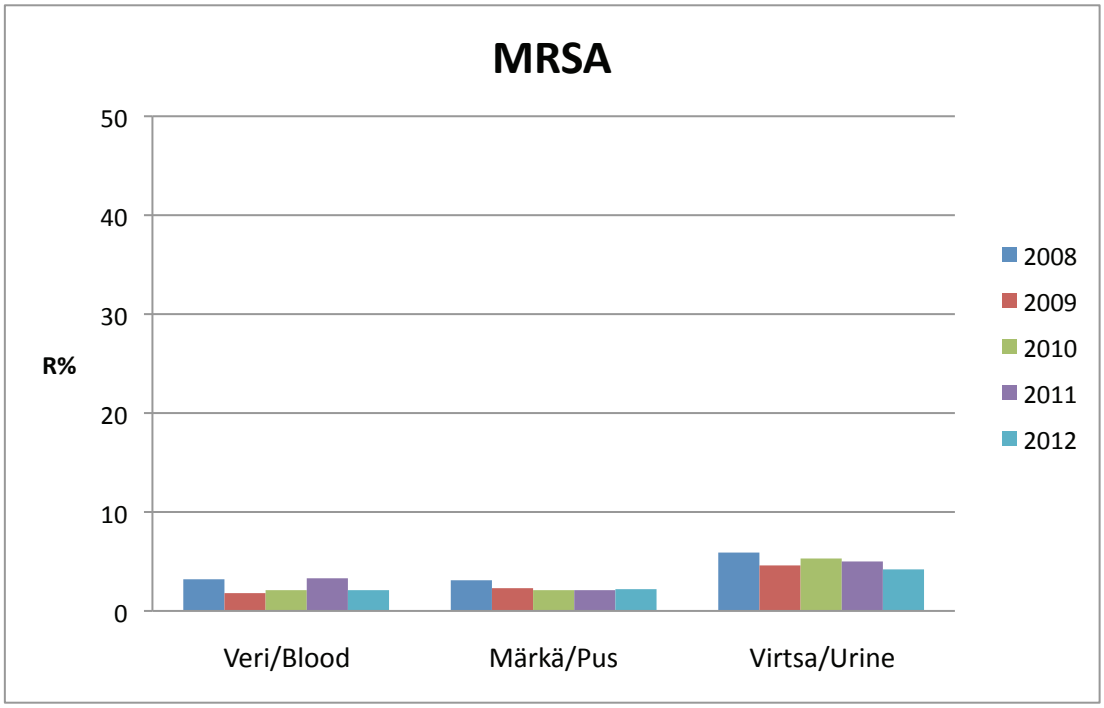

Figure 23. Proportion of MRSA strains in *S. aureus* strains in different types of clinical isolates 2008–2012.

The proportion of MRSA strains in blood and pus isolates has remained at a relatively low level, at around 2–3%, while the proportion of MRSA strains in urine isolates is higher (Table 23a). The results from the Pirkanmaa Hospital District raise the total MRSA percentage in Finland. In 2008–2012, the MRSA percentages in Pirkanmaa were clearly above the national average for all the clinical isolates (Table 23b).

Table 23. Proportion of MRSA strains in *S. aureus* blood, pus and urine isolates and total number of strains tested.

a) Finland, total						
Clinical isolates		**2008**	**2009**	**2010**	**2011**	**2012**
Veri/Blood	tested	1 248	1 245	1 387	1 314	1 510
	MRSA%	3.2	1.8	2.1	3.3	2.1
Märkä/Pus	tested	32 046	31 877	33 175	31 786	32 935
	MRSA%	3.1	2.3	2.1	2.1	2.2
Virtsa/Urine	tested	2 733	2 612	2 610	2 388	2 556
	MRSA%	5.9	4.6	5.3	5.0	4.2
b) Pirkanmaa						
Clinical isolates		2008	2009	2010	2011	2012
Veri/Blood	tested	115	86	149	157	159
	MRSA%	13.0	12.8	8.1	14.0	7.5
Märkä/Pus	tested	2 378	2 273	2 413	2 496	2 316
	MRSA%	7.6	5.2	6.7	6.6	5.9
Virtsa/Urine	tested	324	280	374	321	323
	MRSA%	25.9	17.1	21.7	19.9	18.6

13. *Streptococcus pneumoniae*

In 2012, the FiRe laboratories examined 3 843 *Streptococcus pneumoniae* strains, of which 712 were isolated from blood samples. A total of 1 493 *S. pneumoniae* strains were isolated from samples collected from children aged under 5.

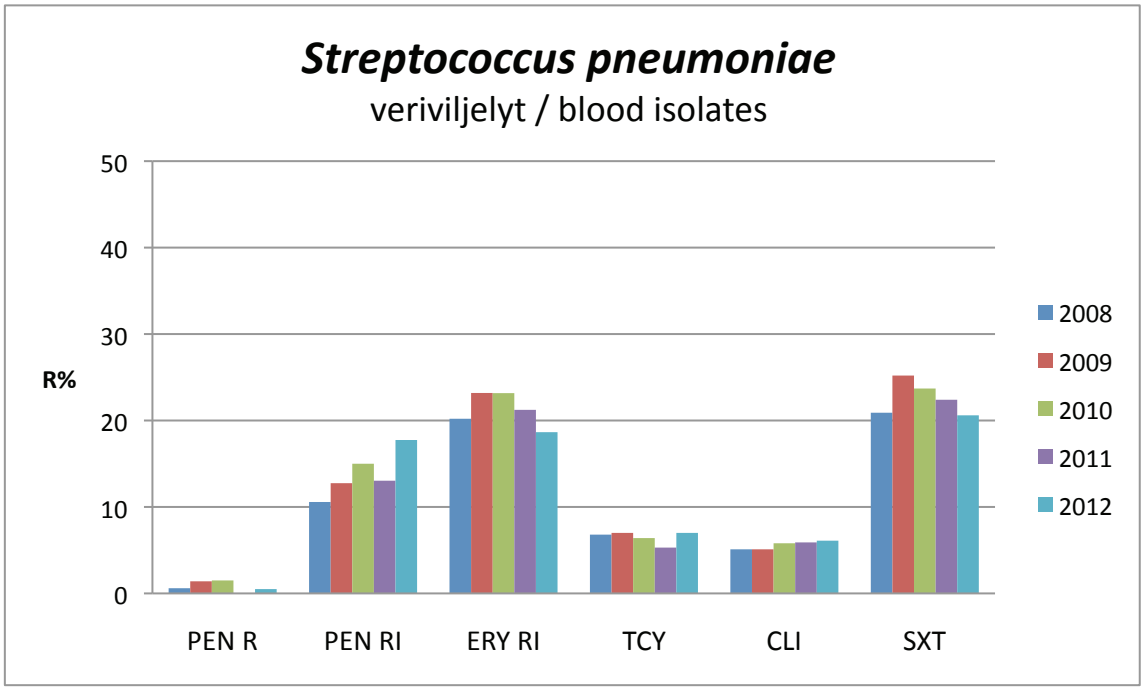

Figure 24. Antimicrobial resistance in *S. pneumoniae* blood isolates in 2008–2012.

In this report, the general EUCAST clinical breakpoints (v1.3 and v2.0) are used also for *S. pneumoniae* (pneumococcus) strains isolated from blood cultures. Penicillin resistance of pneumococcus has remained low (0.0–1.5%), while the proportion of penicillin-non-susceptible strains has increased over the five-year period, reaching 17.7% in 2012. The drop in the proportion of resistant strains (MIC >2 mg/l) is explained by the new EUCAST clinical breakpoints. Before, the CLSI-based MIC breakpoint for resistance was ≥2 mg/l. However, the new clinical breakpoints have no effect on the proportion of susceptible strains (the MIC breakpoint for susceptibility ≤0.06 mg/l has not changed), which has been declining throughout the five-year period. It is positive that resistance to erythromycin and trimethoprim-sulfa have taken a downward turn.

Table 24. Number and resistance percentages of *S. pneumoniae* blood isolates.

Antimicrobial		**2008**	**2009**	**2010**	**2011**	**2012**
Penicillin	tested	870	800	780	629	603
	R%	0.6	1.4	1.5	0.0	0.5
	RI%	10.6	12.8	15.0	13.0	17.7
Erythromycin	tested	1 084	992	941	763	874
	R%	19.3	22.5	22.4	21.2	18.4
	RI%	20.2	23.2	23.2	21.2	18.6
Tetracycline	tested	532	489	469	379	455
	R%	6.8	7.0	6.4	5.3	7.0
Clindamycin	tested	968	896	846	697	838
	R%	5.1	5.1	5.8	5.9	6.1
Trimethoprim-sulfa	tested	508	488	459	362	427
	R%	20.9	25.2	23.7	22.4	20.6

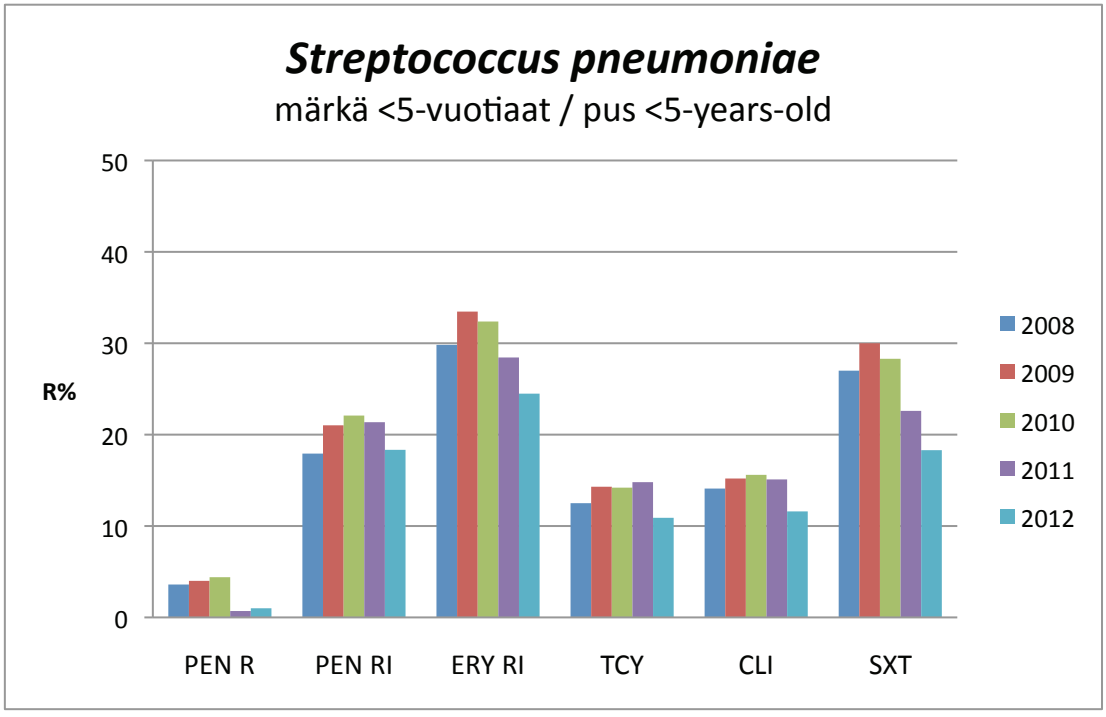

Figure 25. Antimicrobial resistance in *S. pneumoniae* pus isolates collected from children aged under 5 in 2008–2012.

The decline in the number of penicillin-resistant pneumococcus strains in 2010–2011 (from 4.4% to 0.7%) is explained by the EUCAST transition, as described above. The proportion of strains non-susceptible to both penicillin and erythromycin has been decreasing since 2010 (Table 25). Resistance to other antimicrobial agents has also decreased compared with the situation a few years ago. Pneumococcal vaccine for children was included in the Finnish National Vaccination Programme in 2010. The vaccine covers the major "pediatric" serotypes also carrying most of the acquired antimicrobial resistance in this species. The impact of the vaccinations on antimicrobial resistance in pneumococcus will be seen in near future. The Finres surveillance can be used as one indicator of vaccination outcomes.

Table 25. Numbers and resistance percentages of *S. pneumoniae* pus isolates collected from children aged under 5.

Antimicrobial		**2008**	**2009**	**2010**	**2011**	**2012**
Penicillin	tested	2 025	1 822	1 743	1 381	1 287
	R%	3.6	4.0	4.4	0.7	1.0
	RI%	17.9	21.0	22.1	21.4	18.3
Erythromycin	tested	1 975	1 778	1 782	1 670	1 409
	R%	28.3	32.1	31.3	28.4	24.0
	RI%	29.8	33.5	32.4	28.4	24.5
Tetracycline	tested	1 626	1 519	1 029	1 634	1 382
	R%	12.5	14.3	14.2	14.8	10.9
Clindamycin	tested	1 818	1 616	1 689	1 638	1 369
	R%	14.1	15.2	15.6	15.1	11.6
Trimethoprim-sulfa	tested	1 824	1 651	1 704	1 627	1 398
	R%	27.0	30.0	28.3	22.6	18.3

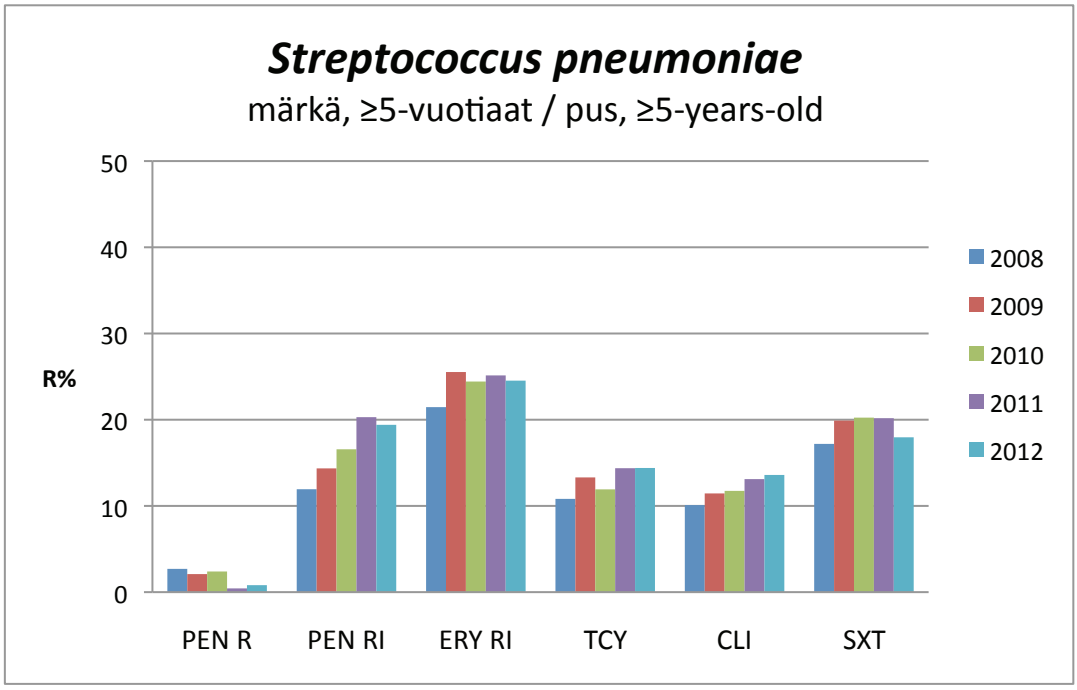

Figure 26. Antimicrobial resistance in *S. pneumoniae* pus isolates collected from patients aged 5 years and over in 2008–2012.

The proportion of penicillin-non-susceptible pneumococcus strains, collected from patients aged 5 years and over, has increased throughout the five-year period, from 11.9% to 19.4%. Resistance to trimethoprim-sulfa has remained around 20%. The steep increase in the erythromycin-non-susceptible strains observed during the first decade of this century has ceased and remains steady at around 24% (Table 26).

Table 26. Numbers and resistance percentages of *S. pneumoniae* pus isolates collected from patients aged 5 years and over.

Antimicrobial		**2008**	**2009**	**2010**	**2011**	**2012**
Penicillin	tested	1 927	1 672	1 545	1 153	1 484
	R%	2.7	2.1	2.4	0.4	0.8
	RI%	11.9	14.4	16.6	20.3	19.4
Erythromycin	tested	1 850	1 602	1 531	1 444	1 602
	R%	20.4	24.0	23.2	25.0	24.3
	RI%	21.5	25.5	24.4	25.1	24.5
Tetracycline	tested	1 627	1 488	1 099	1 433	1 604
	R%	10.8	13.3	11.9	14.4	14.4
Clindamycin	tested	1 783	1 546	1 490	1 434	1 567
	R%	10.1	11.4	11.7	13.1	13.6
Trimethoprim-sulfa	tested	1 768	1 558	1 492	1 393	1 598
	R%	17.2	19.9	20.2	20.2	18.0

14. *Streptococcus pyogenes*

The FiRe laboratories examined 17 637 *Streptococcus pyogenes* strains in 2012. A total of 14 638 of these were isolated from throat samples.

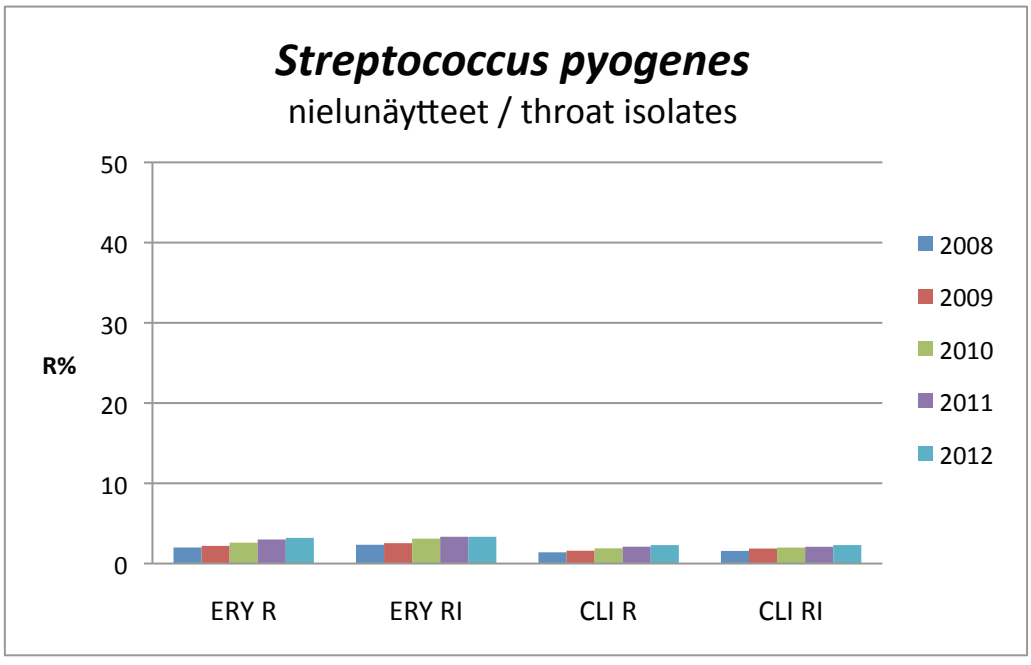

Figure 27. Antimicrobial resistance in *S. pyogenes* throat isolates in 2008–2012.

A slight increase can be detected in the proportion of erythromycin- and clindamycin-resistant *S. pyogenes* strains isolated from throat samples.

Table 27. Numbers and resistance percentages of *S. pyogenes* throat isolates.

Antimicrobial		**2008**	**2009**	**2010**	**2011**	**2012**
Erythromycin	tested	15 166	13 275	13 630	12 979	14 636
	R%	2.0	2.2	2.6	3.0	3.2
	RI%	2.3	2.5	3.1	3.3	3.3
Clindamycin	tested	15 015	13 166	13 507	12 978	14 636
	R%	1.4	1.6	1.9	2.1	2.3
	RI%	1.6	1.9	2.0	2.1	2.3

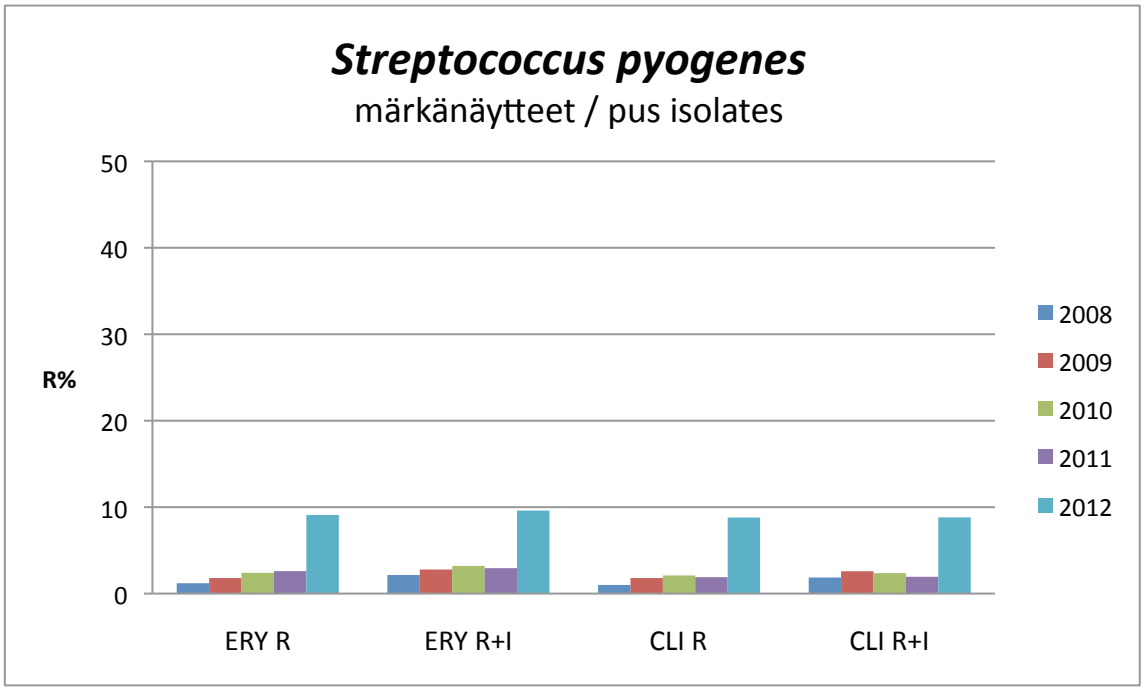

Figure 28. Antimicrobial resistance in *S. pyogenes* pus isolates in 2008–2012.

In 2012, a clear increase could be detected in the proportion of erythromycin-resistant strains isolated from pus samples. The same trend could be detected also for clindamycin-resistant strains, which indicates erm methylases as the resistance mechanism. It is important to note that no similar growth in erythromycin and clindamycin resistance has been detected in strains isolated from throat samples (Figure 27).

Table 28. Numbers and resistance percentages of *S. pyogenes* pus isolates.

Antimicrobial		**2008**	**2009**	**2010**	**2011**	**2012**
Erythromycin	tested	3 023	2 761	2 465	2 548	2 946
	R%	1.2	1.8	2.4	2.6	9.1
	RI%	2.2	2.8	3.2	2.9	9.6
Clindamycin	tested	3 009	2 706	2 449	2 621	3 051
	R%	1.0	1.8	2.1	1.9	8.8
	RI%	1.9	2.6	2.4	1.9	8.8

Annex 1. Abbreviations

S	Susceptible
I	Intermediate
RI	Non-susceptible
R	Resistant
-	Antimicrobial resistance has been tested for <50% of strains
AMC	Amoxicillin-clavulanate
AMP	Ampicillin
CAZ	Ceftazidime
CEP	Cefalothin
CIP	Ciprofloxacin
CLI	Clindamycin
CLSI	Clinical and Laboratory Standards Institute
CRO	Ceftriaxone
CXM	Cefuroxime
ERY	Erythromycin
ESBL	Extended-spectrum β-lactamases
EUCAST	European Committee on Antimicrobial Susceptibility Testing
FUS	Fusidic acid
LEX	Cefalexin
LVX	Levofloxacin
MEC	Mecillinam
MEM	Meropenem
MRSA	Methicillin-resistant *Staphylococcus aureus*
NIT	Nitrofurantoin
NOR	Norfloxacin
OXA	Oxacillin
PEN	Penicillin
RIF	Rifampicin
SXT	Trimethoprim-sulfa
TCY	Tetracycline
TMP	Trimethoprim
TOB	Tobramycin
TZP	Piperacillin-tazobactam
VAN	Vancomycin
VRE	Vancomycin-resistant enterococcus