UK Health Security Agency

Laboratory surveillance of paediatric bloodstream infections and antimicrobial resistance in England: 2017 to 2021

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Contents

Introduction

The purpose of this first edition of a new series of reports highlighting key trends in laboratory reported incidence and antimicrobial resistance (AMR) of a number of key bacterial bloodstream infections (BSI) in the age groups within the paediatric population (0 to 17 years). This report should be viewed as supplementary to the English Surveillance Programme for Antimicrobial Utilisation and Resistance (ESPAUR) Report 2021 to 2022 where methods are listed (1).

The following analysis is based on voluntary surveillance reported by laboratories in England between 2017 and 2021 for key Gram-positive (*Staphylococcus aureus, Streptococcus pneumoniae* and *Enterococcus* spp.) and Gram-negative (*Escherichia coli, Klebsiella pneumoniae, Pseudomonas* spp. and *Acinetobacter* spp.) BSI-causing bacteria in paediatric age-groups (under 1 month, 1 to 11 months, 1 to 4 year olds, 5 to 11 year olds and 12 to 17 year olds).

Data was extracted on 11 April 2022 from the AMR module of the UK Health Security Agency's (UKHSA) Second Generation Surveillance System (SGSS).

Rates of laboratory reported BSI were calculated using Office for National Statistics (ONS) mid-year resident population estimates for the respective year for each respective age group, with under 1 month rates calculated using one twelfth of the 0 years age group and 1 to 11 months rates using eleven twelfths of the 0 years age group (2). Antimicrobial susceptibility trends are based on SGSS AMR data and reported for the period 2017 to 2021.

Data tables are provided in an appendix featuring the data behind the findings of this report.

Main points

Bloodstream infections (BSI) rates

Main results were that:

- in the paediatric population as a whole, *S. pneumoniae* and *Enterococcus* spp. BSI increased whilst *S. aureus* BSI decreased between 2020 and 2021; however, there were differences by age group
- Whilst BSI caused by *S. pneumoniae* increased in all age groups, most notably in the 1 to 4 and 5 to 11 years, BSI caused by *Enterococcus* spp. only increased in children under 1 year old and 12 years or older (there were decreases in rates in children aged 1 to 11 years); BSI caused by *S. aureus* decreased in all age groups (except the neonates) most notably in 1 to 11 month olds
- overall, the rates of Gram-negative BSI increased between 2020 and 2021 in the paediatric population as a whole; for *E. coli* BSI; however, decreases were observed in the 1 to 11 months age group, and among 1 to 11 year-olds

Antimicrobial resistance (AMR)

Main results were that:

- overall in the paediatric population between 2020 and 2021, there were increases in *S. pneumoniae* resistance to penicillin and macrolides, and *Enterococcus* spp. resistance to glycopeptides. Conversely, there was a decrease in *S. aureus* resistance to meticillin, most distinctly in the 1 to 4 years and 12 to 17 years age groups, with decreasing trends in resistance from 2018
- whilst there was a decrease in *Enterococcus* spp. resistance to ampicillin/amoxicillin in the under 1 year olds and those 12 years and over, resistance to glycopeptides only decreased in the neonates
- between 2020 and 2021, in the paediatric population overall, *E. coli* resistance to all antibiotics tested increased (except carbapenems and co-amoxiclav), particularly for gentamicin and third-generation cephalosporins with higher levels of resistance in 2021 than 2017
- there was increasing resistance of *K. pneumoniae* to third-generation cephalosporins and piperacillin with tazobactam in the younger age groups (4 years and under); conversely, resistance rates decreased in the older age groups (5 years and older). There have been increasing trends of *K. pneumoniae* resistance to ciprofloxacin in all age groups since 2017
- *Pseudomonas* spp. resistance to all agents increased except to ciprofloxacin. Of note, the increase of *Pseudomonas* spp. resistance to carbapenems was noted in the older age groups (1 year and older)

Caveats

The caveats are that:

- numbers of isolates tested in the paediatric population are much lower than the adult population, caution should be taken when interpreting resistance rates due to small sample sizes
- the coronavirus (COVID-19) pandemic affected the general case-mix of hospital patients during much of 2020, this has likely impacted trends for the 5-year period
- data presented is not adjusted to account for the occurrence of outbreaks, which could result in over-representation of resistant strains

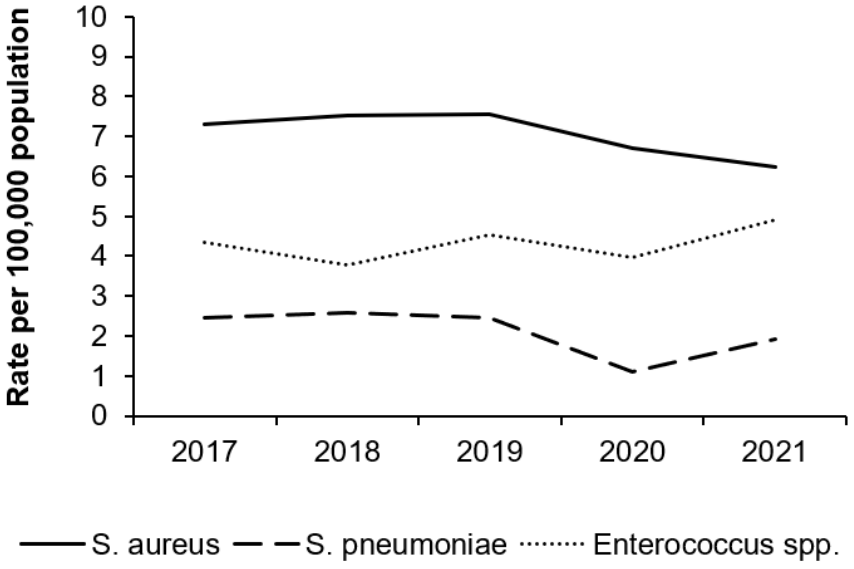
Results

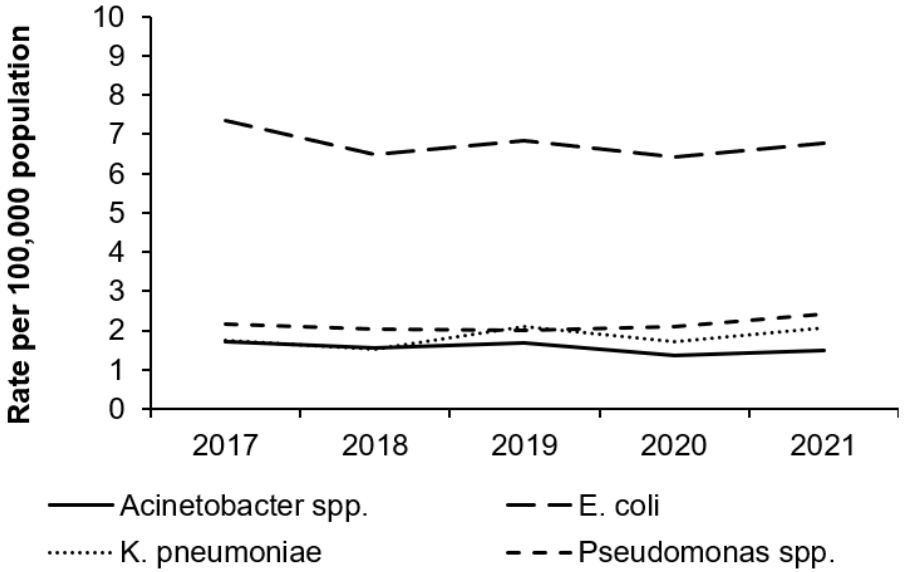
Paediatric population (0 to 17 years)

1.1 BSI rates

Overall rates of BSI caused by *S. pneumoniae* and *Enterococcus* spp. increased between 2020 and 2021 (Figure 1a). Between 2020 and 2021, *S. pneumoniae* rates, which have been declining since 2018, increased from 1.1 to 1.9 per 100,000 population and *Enterococcus* spp. BSI increased from 4.0 to 4.9 per 100,000 population. The rate of *S. aureus* decreased from 6.7 to 6.2 per 100,000 population between 2020 and 2021, following a decreasing trend since 2019 (7.6 per 100,000 population) (Figure 1a). Between 2020 and 2021, rates of *E. coli*, *K. pneumoniae* and *Acinetobacter* spp. BSI increased from 6.4 to 6.8, 1.7 to 2.1 and 1.4 to 1.5 per 100,000 population, respectively, having all seen a decrease in rates between 2019 and 2020 (Figure 1b).

Figure 1. BSI rates per 100,000 population (aged 0 to 17 years) in England: 2017 to 2021. (a) Gram-positive bacteria (*S. aureus, S. pneumoniae* and *Enterococcus* spp.) (b) Gram-negative bacteria (*Acinetobacter* spp., *E. coli*, *K. pneumoniae* and *Pseudomonas* spp.)

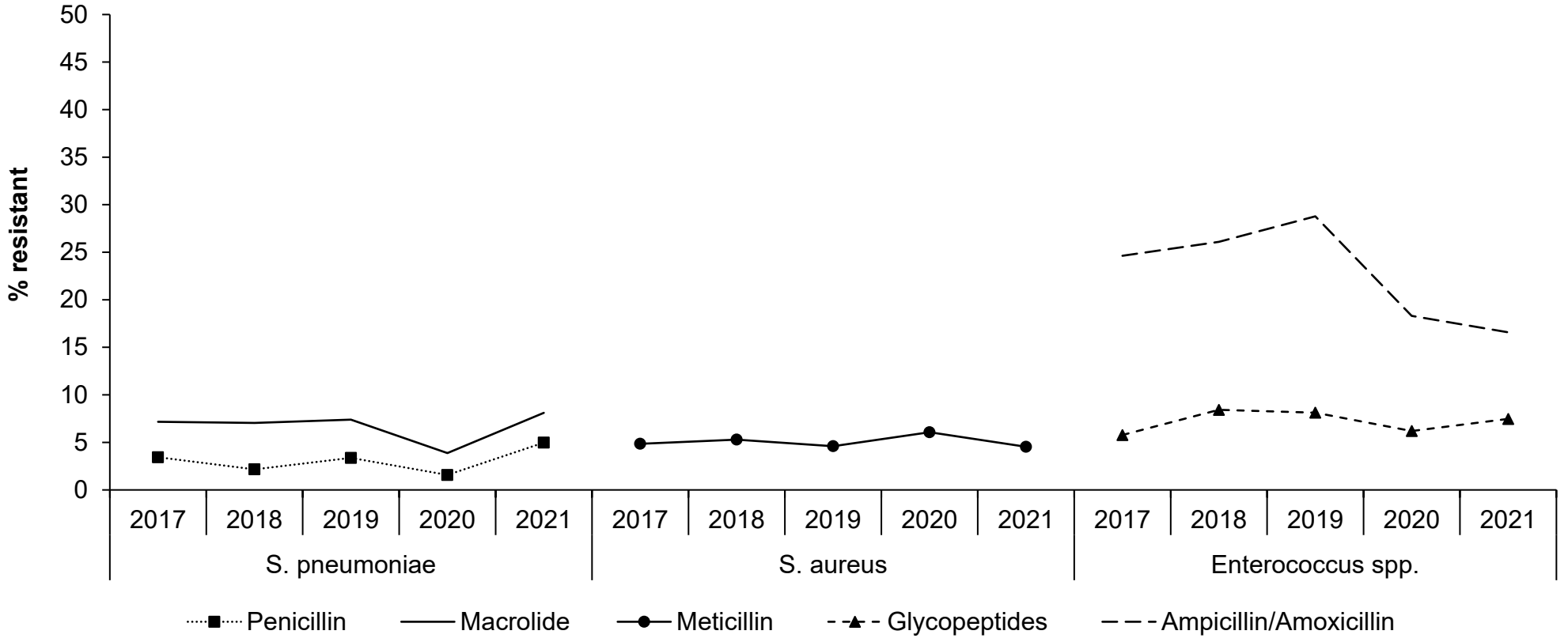




1.2 AMR of Gram-positive BSI

In the paediatric population overall, there was an increase in *S. pneumoniae* resistance to penicillin (1.6% to 5.0%, n=127, 201; n= number of isolates tested) and macrolides (3.9% to 8.1%, n=129, 222) between 2020 and 2021, having seen decreasing trends between 2019 and 2020. A decreasing trend of *Enterococcus* spp. resistance to ampicillin/amoxicillin was seen between 2019 and 2021 (28.8% to 16.6%, n=490, 561) (Figure 2).

Figure 2. AMR of Gram-positive BSI in children aged 0 to 17 years old, England, 2017 to 2021

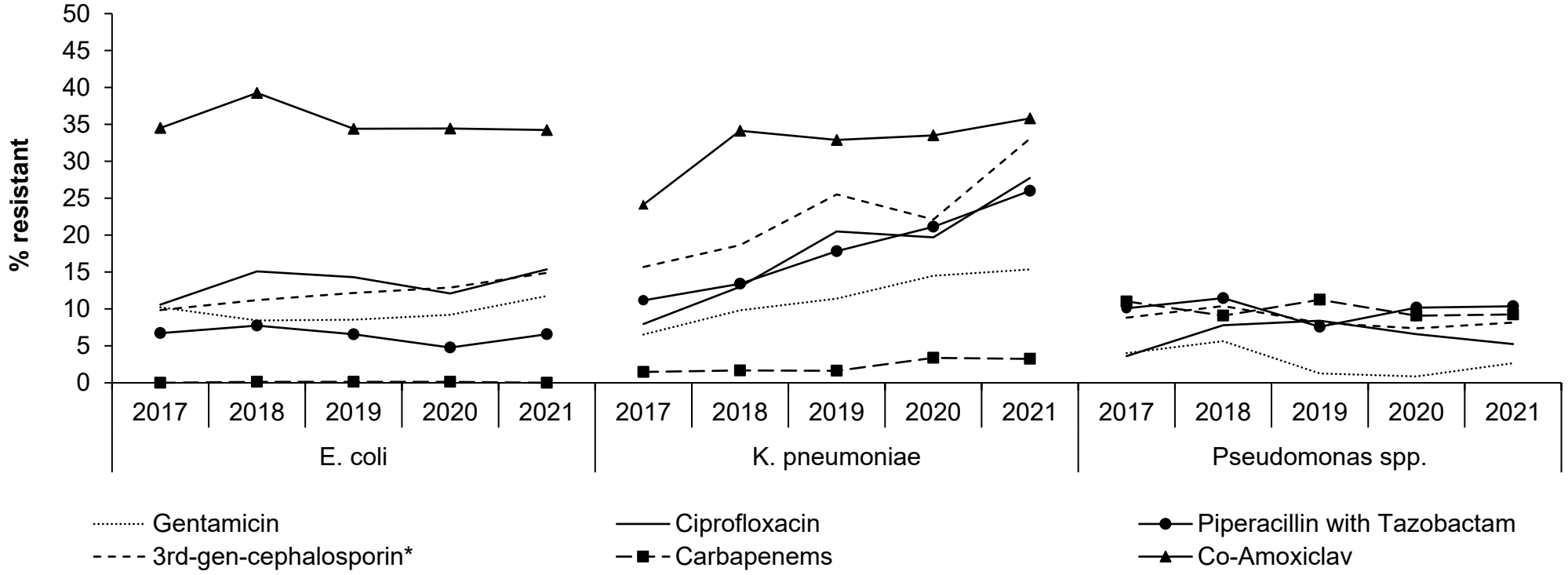


1.3 AMR of Gram-negative BSI

In the paediatric population overall, there was an increase in *E. coli* resistance to third-generation cephalosporins over the 5-year period from 9.9% in 2017 (n=852) to 14.9% (n=813) in 2021. Similar patterns were seen in *K. pneumoniae* resistance to third-generation cephalosporins, increasing from 15.7% (n=204) to 33.1% (n=245) in 2021 (Figure 3).

Resistance of *K. pneumoniae* to piperacillin with tazobactam increased from 11.2% (n=188) in 2017 to 26.0% (n=227) in 2021 (Figure 3). Unlike *E. coli* and *K. pneumoniae*, which both saw an increase in resistance to ciprofloxacin between 2020 and 2021 (12.1% n=744 to 15.4% n=788, 19.7% n=203 to 27.7% n=238), there was a decrease in *Pseudomonas* spp. resistance to ciprofloxacin between 2020 and 2021, following a downwards trend since 2019 (2019: 8.4% n=238, 2021: 5.2% n=286) (Figure 3).

Figure 3. AMR of Gram-negative BSI in children aged 0 to 17 years old, England, 2017 to 2021



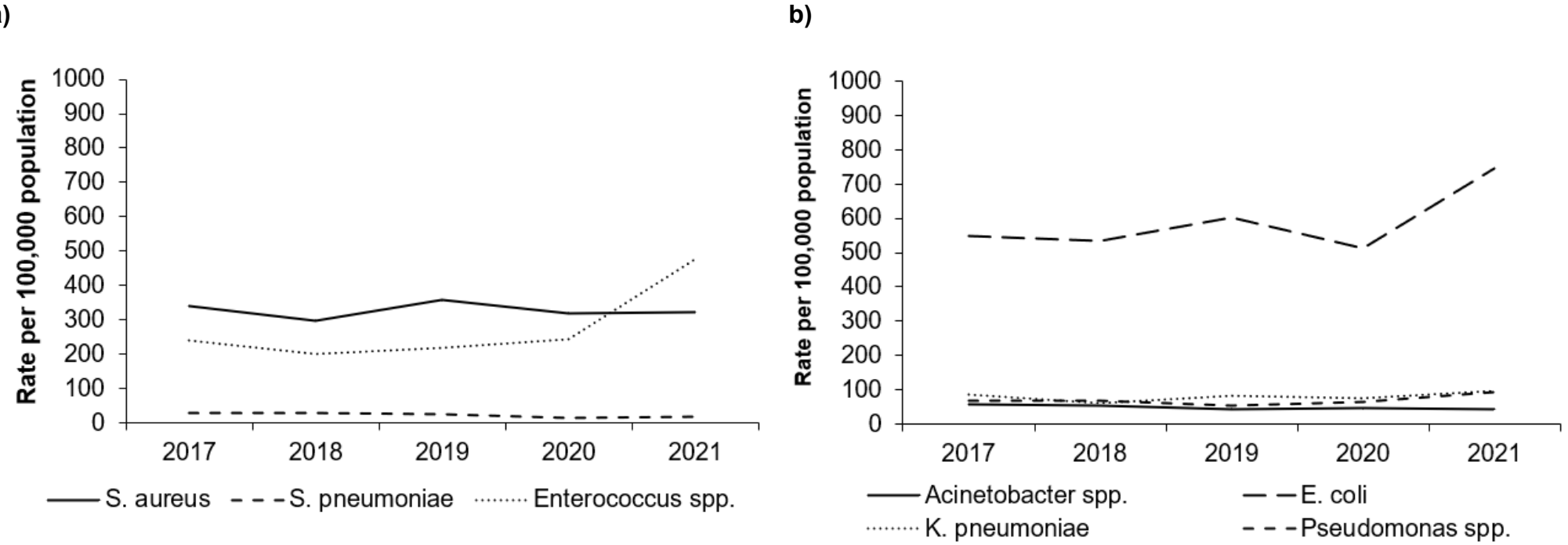
* Third-generation cephalosporins: cefotaxime, ceftazidime, ceftriaxone or cefpodoxime; except for *Pseudomonas* spp. where only ceftazidime is looked at.

Neonates (less than 1 month)

2.1 BSI rates

Rates of *S. aureus* and *S. pneumoniae* BSI remained relatively stable in neonates between 2020 and 2021 (Figure 4a). There was an increase in the rate of *Enterococcus* spp., between 2020 to 2021 from 243.2 to 474.5 per 100,000 population (95.1% increase) (Figure 4a). There was an increase in BSI caused by Gram-negative bacteria *K. pneumoniae* and *Pseudomonas* spp. between 2020 and 2021 (73.8 to 95.7 and 65.8 to 93.7 per 100,000 population, respectively). Between 2020 and 2021, *E. coli* rates increased from 514.4 to 747.6 per 100,000 population in 2021 (45.3% increase) (Figure 4b).

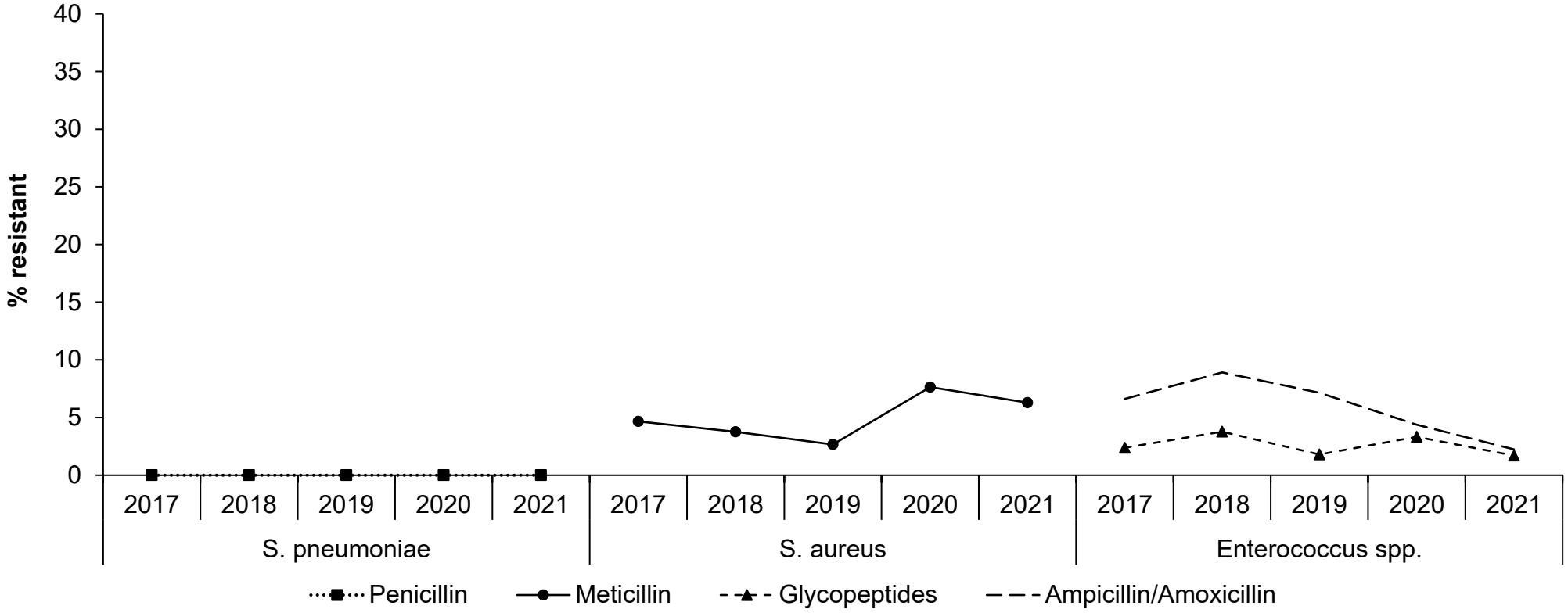
Figure 4. BSI rates per 100,000 population (less than 1 month) in England: 2017 to 2021. (a) Gram-positive bacteria (*S. aureus, S. pneumoniae* and *Enterococcus* spp.) (b) Gram-negative bacteria (*Acinetobacter* spp., *E. coli*, *K. pneumoniae* and *Pseudomonas* spp.)



2.2 AMR of Gram-positive BSI

Between 2017 and 2021, resistance of *S. pneumoniae* to penicillin remained at 0%, with a number of non-susceptible isolates detected in 2021 (44.4% n=9) (see accompanying data tables). There was a decrease in *Enterococcus* spp. resistance to ampicillin/amoxicillin between 2020 and 2021 (4.4% n=114 to 2.2% n=223), continuing a downwards trend from 8.9% in 2018 (n=101) (Figure 5).

Figure 5. AMR of Gram-positive BSI in children aged less than 1 month, England, 2017 to 2021

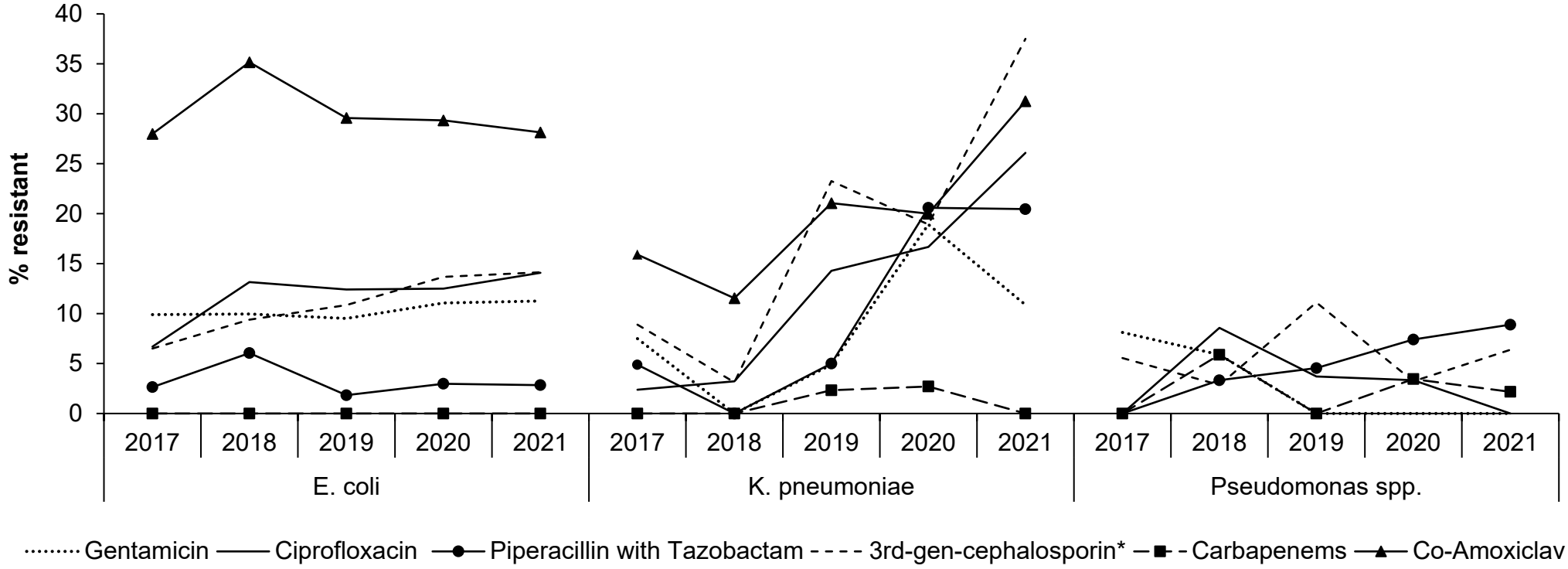


* Macrolides excluded as not routinely used in this age group.

2.3 AMR of Gram-negative BSI

In neonates, resistance of *E. coli* to third-generation cephalosporins followed an upwards trend between 2017 to 2021 (6.5% n=292 to 14.1% n=375). Similarly, there was an increase in *K. pneumoniae* resistance to third-generation cephalosporins between 2020 and 2021, albeit the number of specimens tested was lower (18.9% n=37 to 37.5% n=48). After a decrease in *Pseudomonas* spp. resistance to third-generation cephalosporins between 2019 and 2020, there was an increase in resistance in 2021 (6.4% in 2021 n=47) (Figure 6). *K. pneumoniae* resistance to ciprofloxacin increased between 2020 and 2021 (16.7% n=36 to 26.1% n=46), following an upwards trend from 2017 (2.4% n=42). There was also an increase in *K. pneumoniae* resistance to co-amoxiclav between 2020 and 2021, following an upwards trend from 2018 (11.5% n=26 in 2018 to 31.3% n=48 in 2021) (Figure 6).

Figure 6. AMR of Gram-negative BSI in children aged less than 1 month, England, 2017 to 2021



* Third-generation cephalosporins: cefotaxime, ceftazidime, ceftriaxone or cefpodoxime; except for *Pseudomonas* spp. where only ceftazidime is looked at.

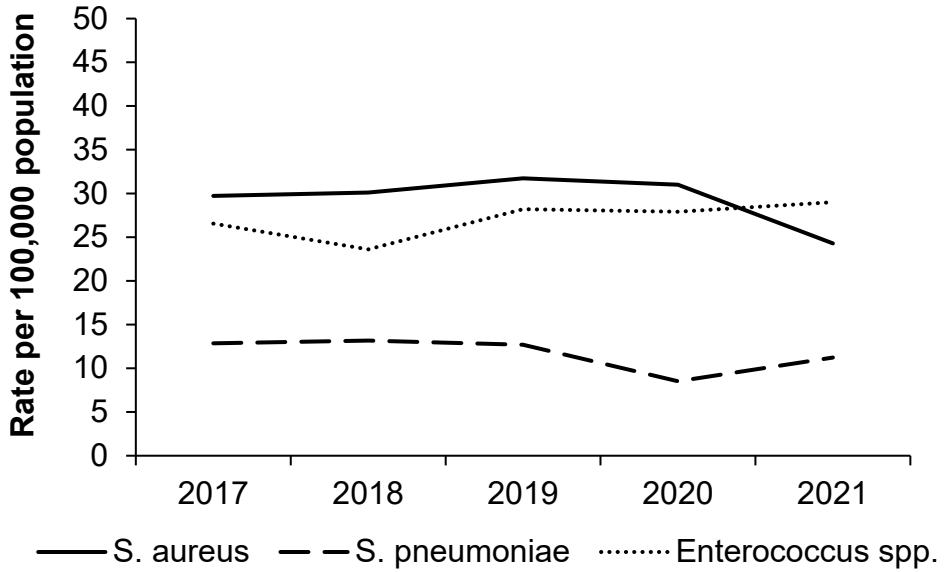
1 to 11 months

3.1 BSI rates

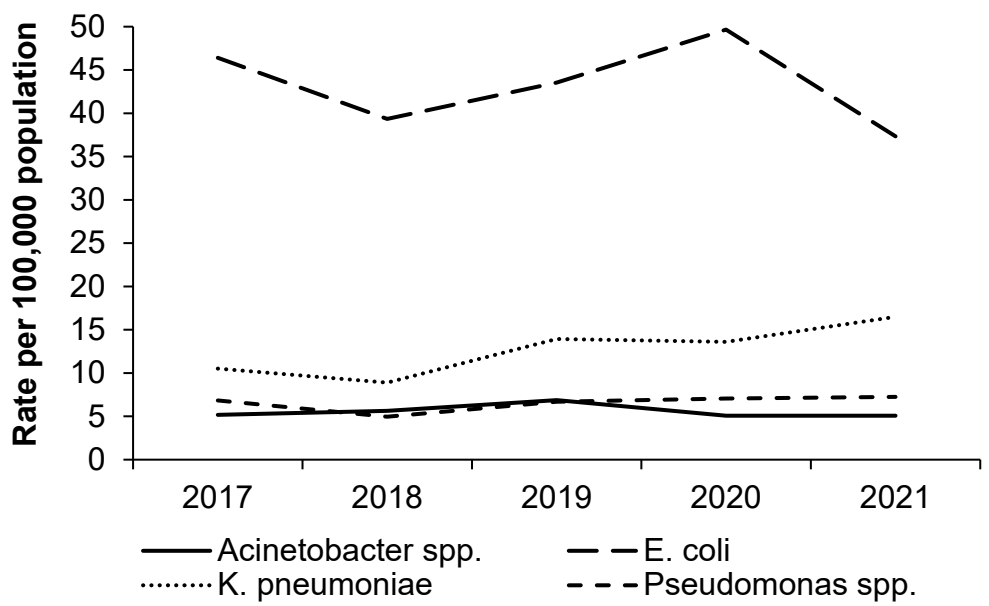
Between 2020 and 2021, BSI caused by *S. aureus* decreased from 31.0 to 24.3 per 100,000 population. Conversely, rates of *S. pneumoniae* saw an increase from 8.5 to 11.2 per 100,000 population. Rates of *Enterococcus* spp. remained relatively stable between 2019 to 2021 (Figure 7a). There was a decrease in rates of *E. coli* BSI between 2020 and 2021, from 49.7 to 37.3 per 100,000 population. There was an increase in the rate of *K. pneumoniae* from 13.6 to 16.5 per 100,000 population between 2020 and 2021. Rates of *Acinetobacter* spp. and *Pseudomonas* spp. remained stable between the same time period (Figure 7b).

Figure 7. BSI rates per 100,000 children aged 1 to 11 months in England: 2017 to 2021. (a) Gram-positive bacteria (*S. aureus, S. pneumoniae* and *Enterococcus* spp.) (b) Gram-negative bacteria (*Acinetobacter* spp., *E. coli*, *K. pneumoniae* and *Pseudomonas* spp.)

a)



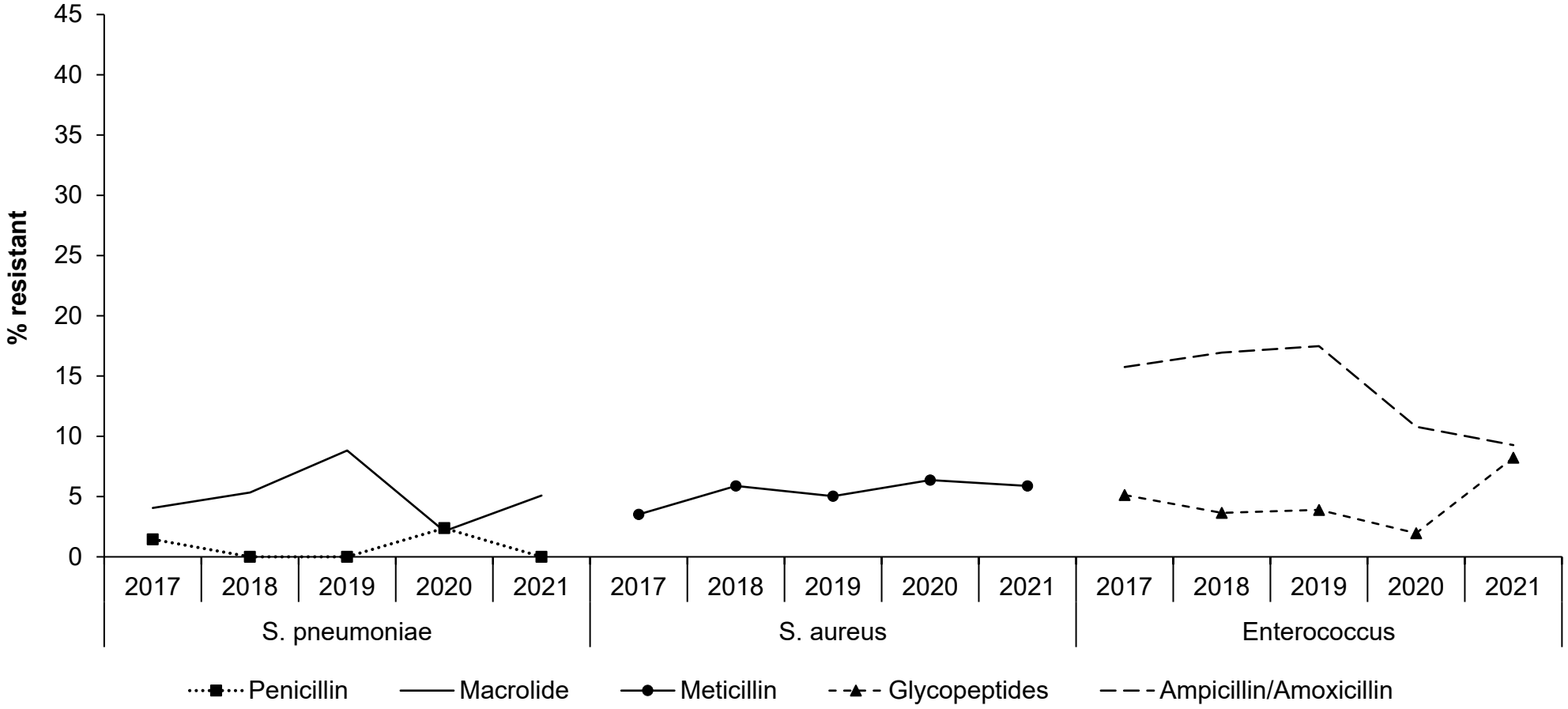
b)



3.2 AMR of Gram-positive BSI

Resistance of *S. pneumoniae* to macrolides remained stable, given the small numbers tested, between 2017 (4.1%, n=74) and 2021 (5.1%, n=59). Similar to resistance patterns seen in the neonates, there was a decrease in *Enterococcus* spp. resistance to ampicillin/amoxicillin between 2019 and 2021 (17.5% n=143 to 9.3% n=151). *Enterococcus* spp. saw an increase in resistance to glycopeptides between 2020 (2.0% n=153) and 2021 (8.2% n=158) (Figure 8).

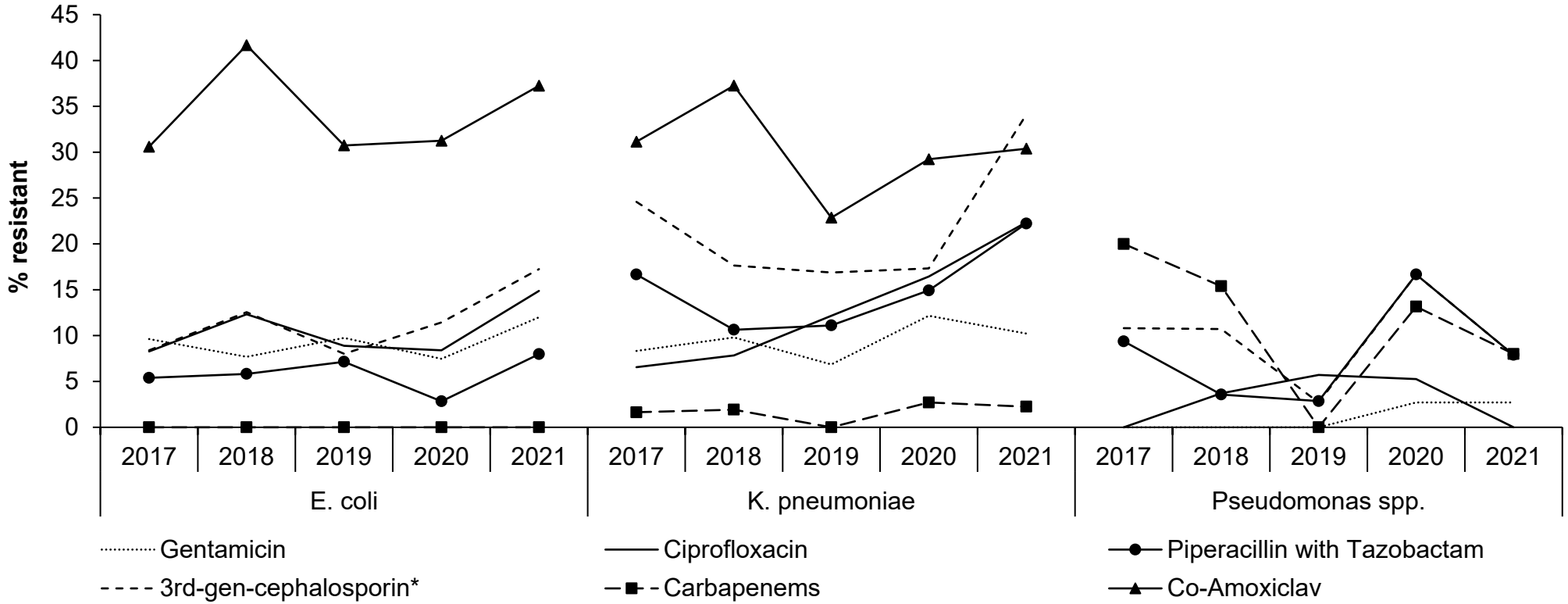
Figure 8. AMR of Gram-positive BSI in children aged 1 to 11 months, England, 2017 to 2021



3.3 AMR of Gram-negative BSI

Between 2020 and 2021, *E. coli* resistance to all antibiotics tested (gentamicin, ciprofloxacin, piperacillin-tazobactam, third-generation cephalosporins and co-amoxiclav) increased and has surpassed levels seen in 2017, with the exception of *E. coli* resistance to carbapenems, which remained at 0% between 2017 to 2021. Between 2020 and 2021, *K. pneumoniae* resistance to third-generation cephalosporins (17.3% n=75 to 34.1% n=88) and piperacillin with tazobactam (14.9% n=67 to 22.2% n=81) increased, following upwards trends from 2019 and 2018, respectively (16.9% n=77 and 10.6% n=47). There was an upwards trend in *K. pneumoniae* resistance to ciprofloxacin between 2017 to 2021 (6.6% n=61 to 22.4% n=85) (Figure 9).

Figure 9. AMR of Gram-negative BSI in children aged 1 to 11 months, England, 2017 to 2021



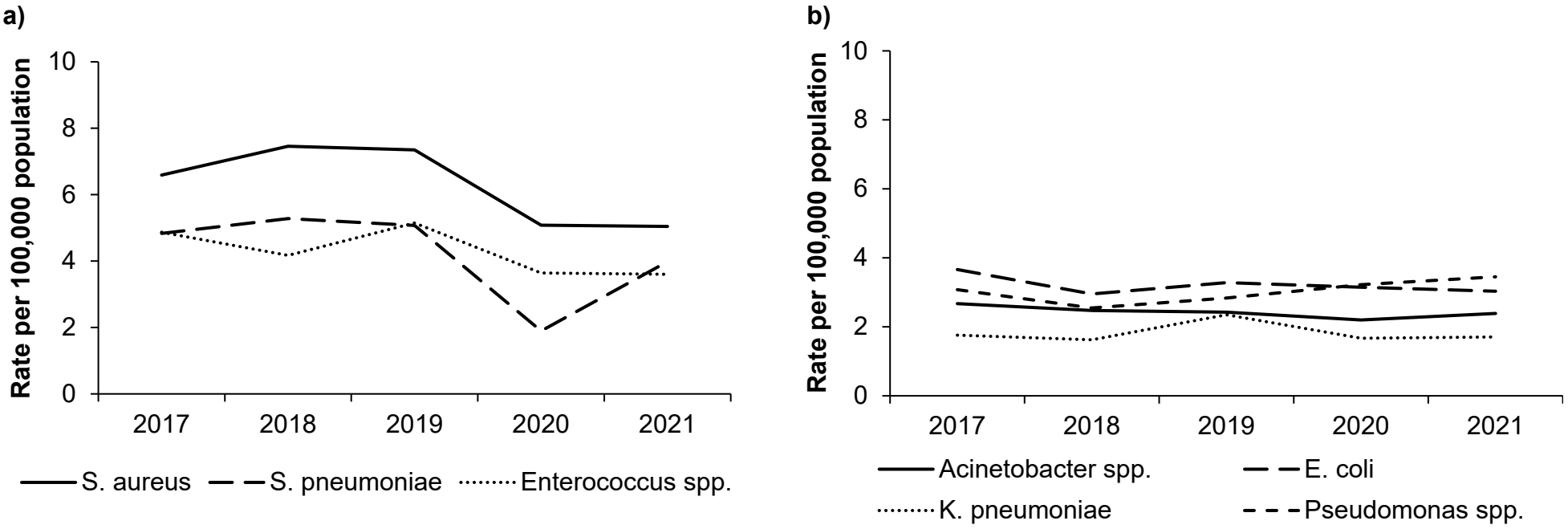
* Third-generation cephalosporins: cefotaxime, ceftazidime, ceftriaxone or cefpodoxime; except for *Pseudomonas* spp. where only ceftazidime is looked at.

1 to 4 years

4.1 BSI rates

In the 1 to 4 year old age group, *S. aureus* rates remained stable between 2020 and 2021 (5.1 to 5.0 per 100,000 population), following a decrease from 2018 (7.5 per 100,000 population). Between 2020 and 2021, there was an increase in the rate of *S. pneumoniae* in this age group (1.9 to 4.0 per 100,000 population), having seen a decrease between 2018 and 2020 (5.3 to 1.9 per 100,000 population). Although rates of *Enterococcus* spp. remained stable between 2020 and 2021, there was a decrease overall from 2017 to 2021 (4.9 to 3.6 per 100,000 population) (Figure 10a). Between 2020 and 2021, there was a slight increase in *Acinetobacter* spp. BSI from 2.2 to 2.4 per 100,000 and a slight increase in *Pseudomonas* spp. BSI (3.2 to 3.5 per 100,000 population). The rate of *E. coli* BSI remained relatively stable between 2020 to 2021 (3.1 to 3.0 per 100,000 population), following the continued downwards trend from 2017 (3.7 per 100,000 population) (Figure 10b).

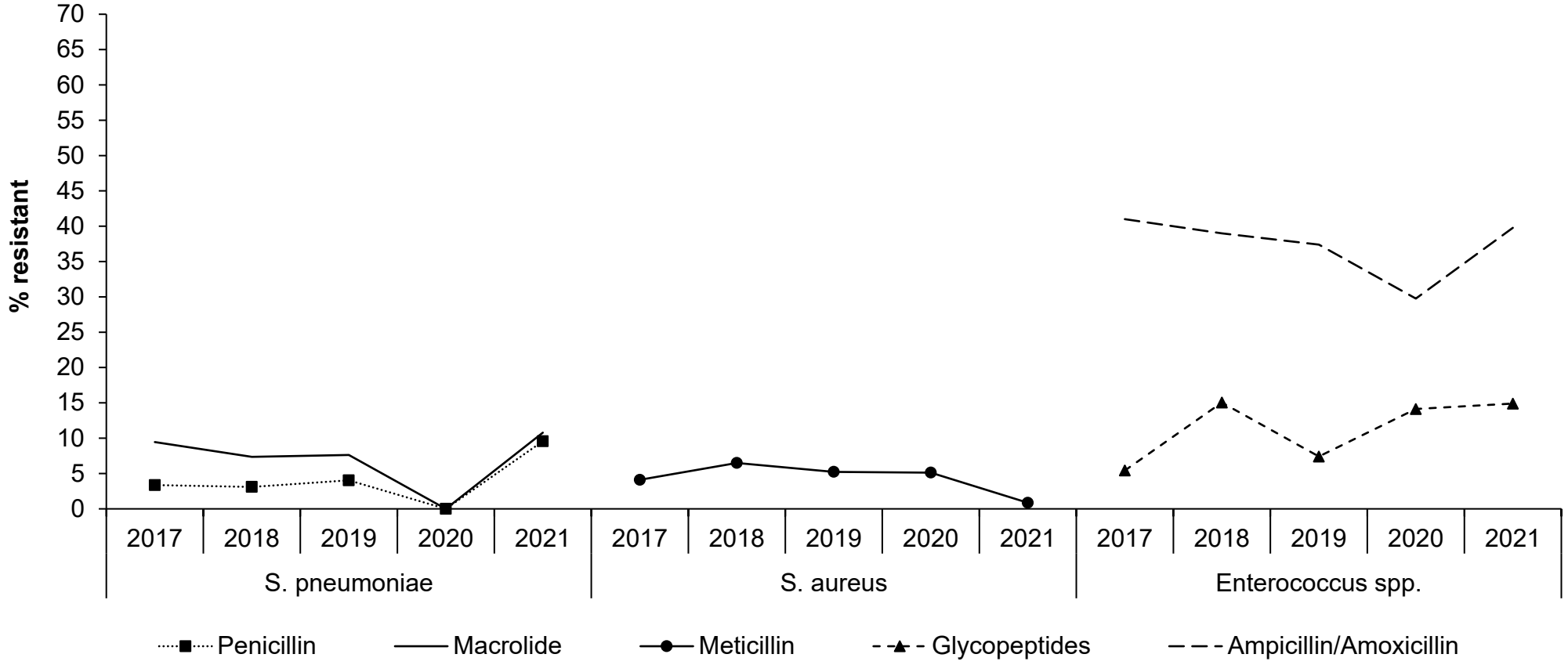
Figure 10. BSI rates per 100,000 children aged 1 to 4 years in England: 2017 to 2021. (a) Gram-positive bacteria (*S. aureus, S. pneumoniae* and *Enterococcus* spp.) (b) Gram-negative bacteria (*Acinetobacter* spp., *E. coli*, *K. pneumoniae* and *Pseudomonas* spp.)



4.2 AMR of Gram-positive BSI

As with the younger age groups, in the 1 to 4 years, resistance of *S. pneumoniae* to macrolides saw an increase between 2020 and 2021 (from 0% n=47 to 10.8% n=102), after a decrease between 2017 and 2020 (9.4% n=127 to 7.6% n=131) (Figure 11). There was an increase in resistance of *S. pneumoniae* to penicillin to levels higher than those seen pre-pandemic (9.6% resistant in 2021 n=94), compared to 3.4% in 2017 (n=119). Between 2020 and 2021 resistance of *Enterococcus* spp. to ampicillin/amoxicillin increased to 39.8% (n=88), having been on a decreasing trajectory since 2017 (2017: 41.0% n=122 to 2020: 29.8% n=84).

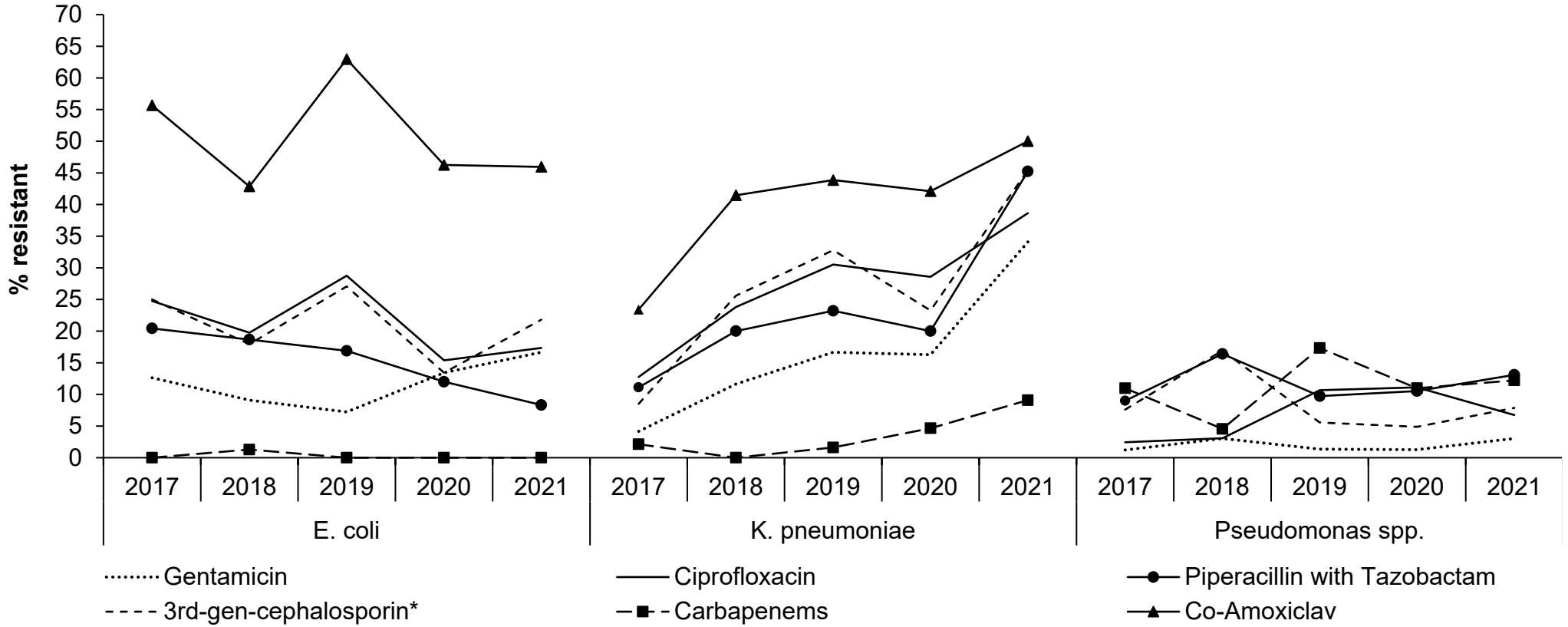
Figure 11. AMR of Gram-positive BSI in children aged 1 to 4 years, England, 2017 to 2021



4.3 AMR of Gram-negative BSI

In the 1 to 4 year olds, between 2020 and 2021, *E. coli* resistance to piperacillin with tazobactam decreased from 12.0% (n=75) to 8.3% (n=72), following a decreasing trend from 2017 (20.4% n=93). There were increasing trends of *K. pneumoniae* resistance to all antibiotics tested between 2020 and 2021 (gentamicin 16.3% n=43 to 34.1% n=44, ciprofloxacin 28.6% n=42 to 38.6% n=44, piperacillin with tazobactam 20.0% n=40 to 45.2% n=42, third-generation cephalosporins 23.3% n=43 to 45.5% n=44, carbapenems 4.7% n=43 to 9.1% n=44, co-amoxiclav 42.1% n=38 to 50.0% n=42), following upwards trends since 2017 (Figure 12).

Figure 12. AMR of Gram-negative BSI in children aged 1 to 4 years, England, 2017 to 2021



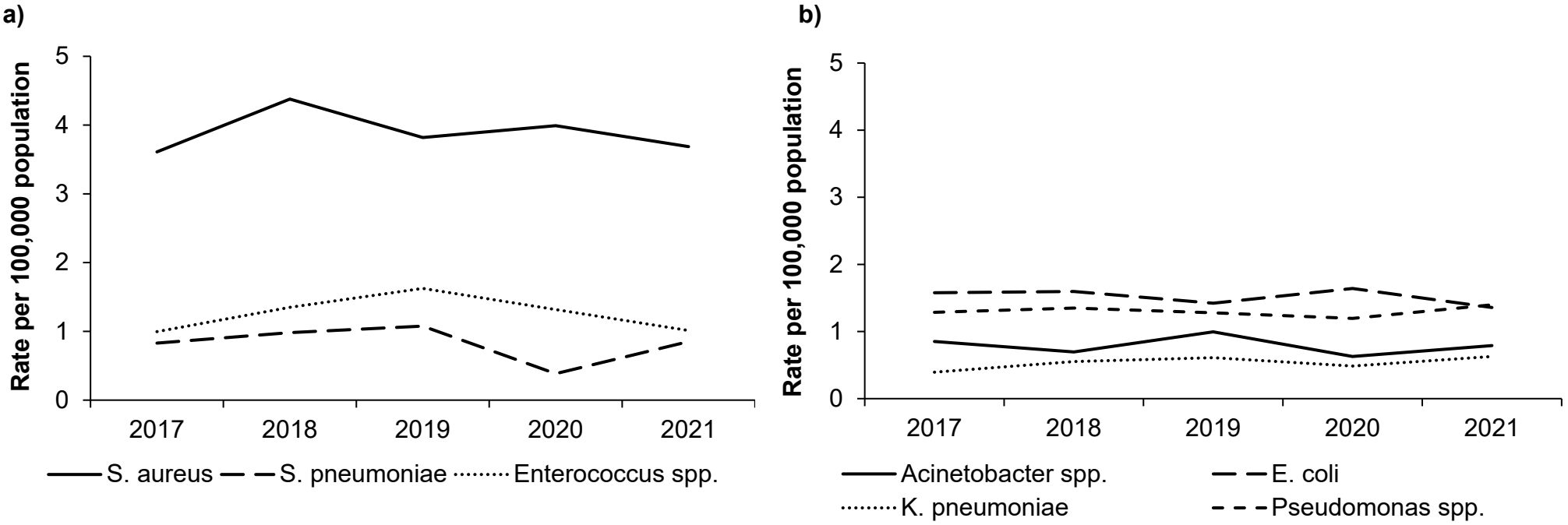
* Third-generation cephalosporins: cefotaxime, ceftazidime, ceftriaxone or cefpodoxime; except for *Pseudomonas* spp. where only ceftazidime is looked at.

5 to 11 years

5.1 BSI rates

There was an increase in *S. pneumoniae* BSI in 5 to 11 years olds between 2020 and 2021 (0.4 to 0.9 per 100,000 population), returning to rates seen pre-2020. There were decreases in the rates of *S. aureus* and *Enterococcus* spp. between 2020 and 2021 (4.0 to 3.7 and 1.3 to 1.0 per 100,000 population, respectively), returning to rates seen pre-2020 (Figure 13a). There were slight increases in BSI caused by *Acinetobacter* spp. and *K. pneumoniae* between 2020 and 2021 (0.6 to 0.8 and 0.5 to 0.6 per 100,000 population, respectively) and a slight decrease in *E. coli* rates (1.6 to 1.4 per 100,000 population) (Figure 13b).

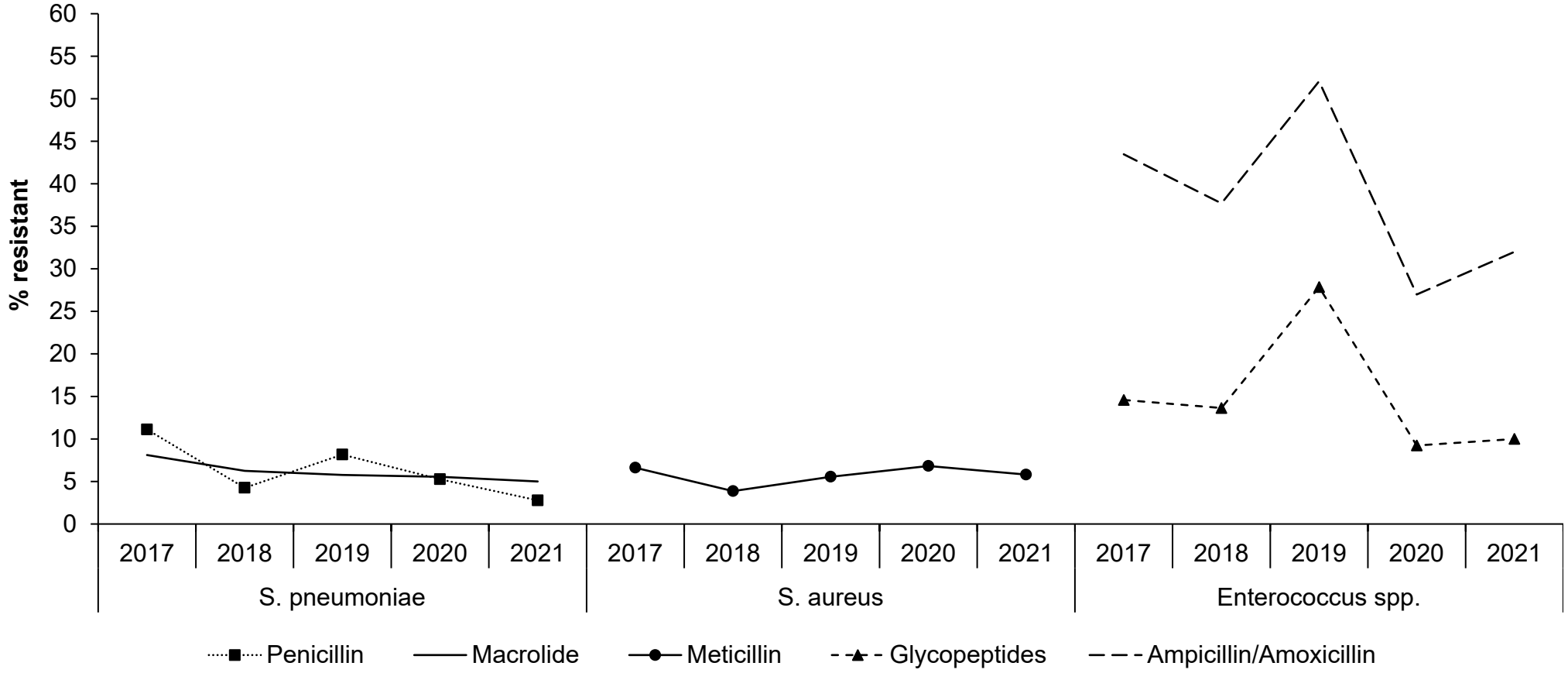
Figure 13. BSI rates per 100,000 children aged 5 to 11 years in England: 2017 to 2021. (a) Gram-positive bacteria (*S. aureus, S. pneumoniae* and *Enterococcus* spp.) (b) Gram-negative bacteria (*Acinetobacter* spp., *E. coli*, *K. pneumoniae* and *Pseudomonas* spp.)



5.2 AMR of Gram-positive BSI

In the 5 to 11 years old age group, between 2020 and 2021, there was an increase in *Enterococcus* spp. resistance to glycopeptides (9.2% n=65 to 10.0% n=50) and to ampicillin/amoxicillin (27.0% n=63 to 32% n=50), following a spike in 2019, as well as decreases in *S. pneumoniae* to penicillin (5.3% n=19 to 2.8% n=36) and macrolides (5.6% n=18 to 5.0% n=40) (Figure 14).

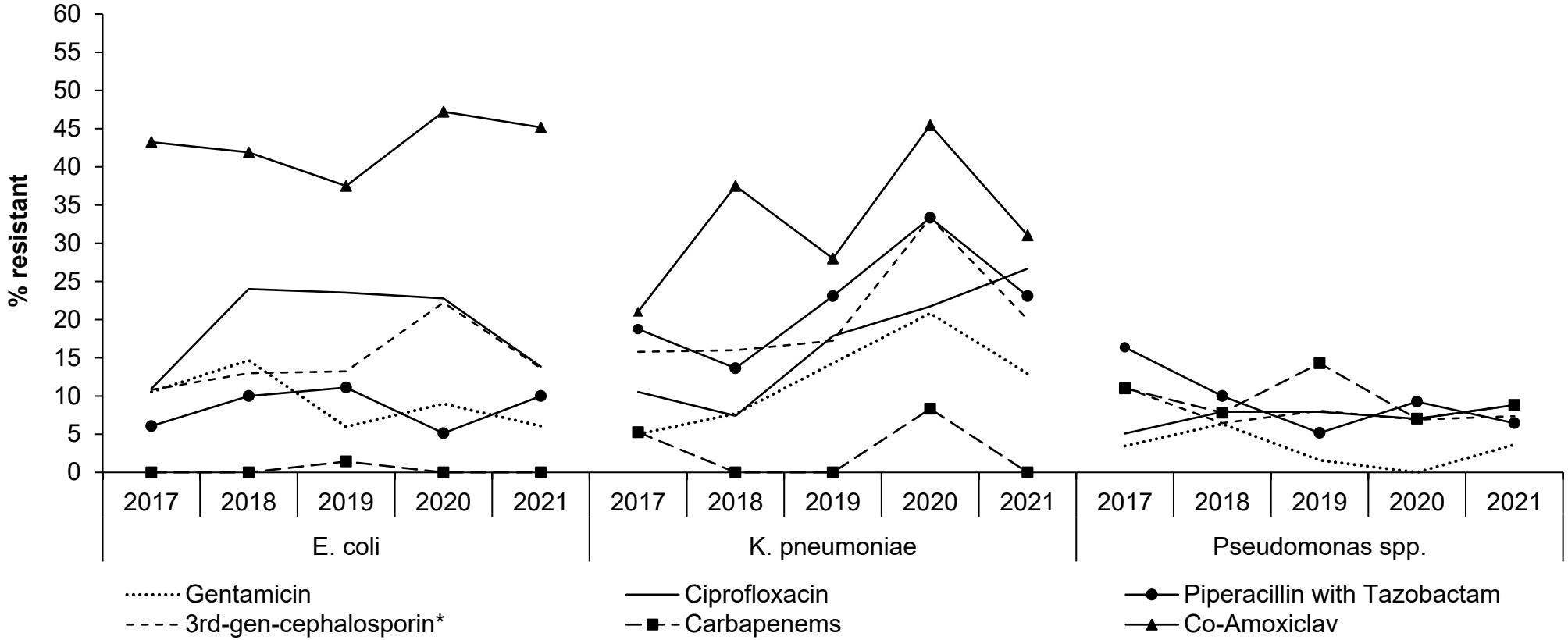
Figure 14. AMR of Gram-positive BSI in children aged 5 to 11 years, England, 2017 to 2021



5.3 AMR of Gram-negative BSI

There was an increase in *E. coli* resistance to piperacillin with tazobactam between 2020 and 2021 (5.1% n=78 to 10.0% n=60), returning to levels seen pre-pandemic (10.0% n=70 in 2018). Resistance of *E. coli* to all other antibiotics tested decreased between 2020 and 2021 (gentamicin 9.0% n=78 to 6.1% n=66, ciprofloxacin 22.8% n=79 to 13.8% n=65, third-generation cephalosporins 22.2% n=81 to 13.6% n=66, co-amoxiclav 47.2% n=72 to 45.2% n=62). Between 2020 and 2021, there was an increase in *K. pneumoniae* resistance to ciprofloxacin (21.7% n=23 to 26.7% n=30), continuing the upwards trend since 2018 (7.4% n=27), whilst resistance to the other agents tested all decreased (Figure 15).

Figure 15. AMR of Gram-negative BSI in children aged 5 to 11 years, England, 2017 to 2021



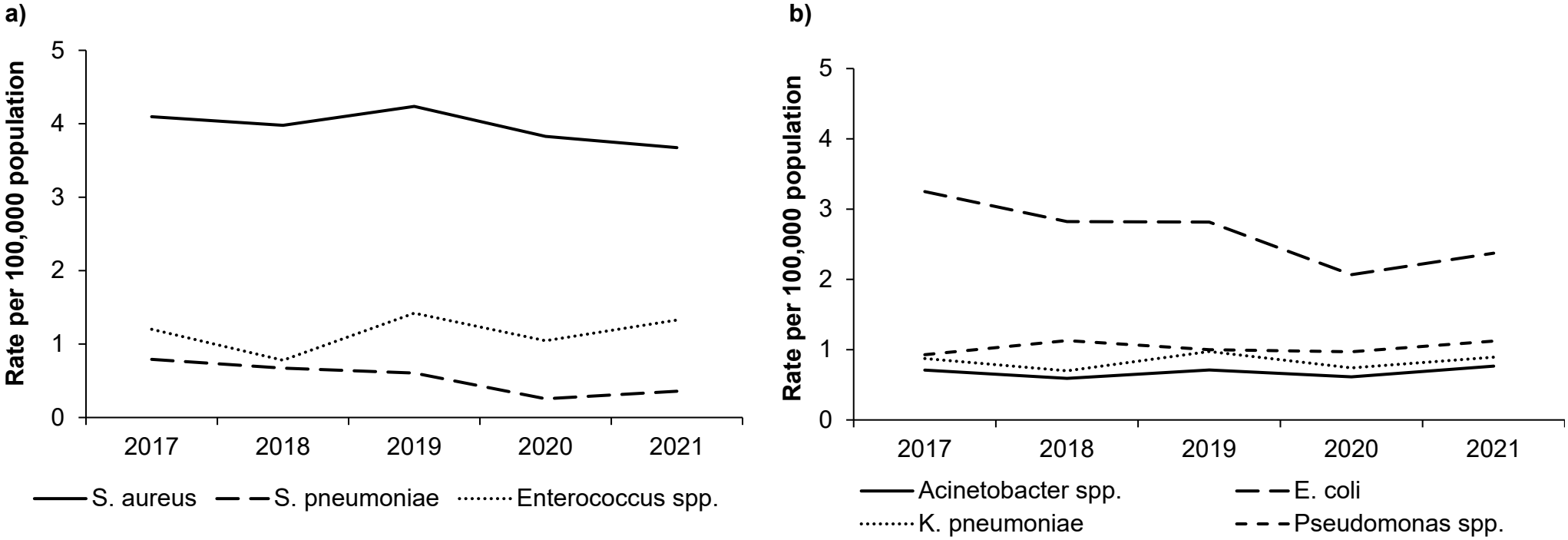
* Third-generation cephalosporins: cefotaxime, ceftazidime, ceftriaxone or cefpodoxime; except for *Pseudomonas* spp. where only ceftazidime is looked at.

12 to 17 years

6.1 BSI rates

Between 2020 and 2021, there was a slight decrease in *S. aureus* BSI rates (3.8 to 3.7 per 100,000 population), following a downwards trend since 2019 (4.2 per 100,000 population). The rate of *S. pneumoniae* increased slightly between 2020 and 2021 (0.3 to 0.4 per 100,000 population) after a decrease in BSI rates since 2017 (0.8 per 100,000 population) (Figure 16a). Between 2020 and 2021, there was an increase in rates of *E. coli, K. pneumoniae, Pseudomonas* spp. and *Acinetobacter* spp. (2.1 to 2.4, 0.7 to 0.9, 1.0 to 1.1 and 0.6 to 0.8 per 100,000 population respectively (Figure 16b).

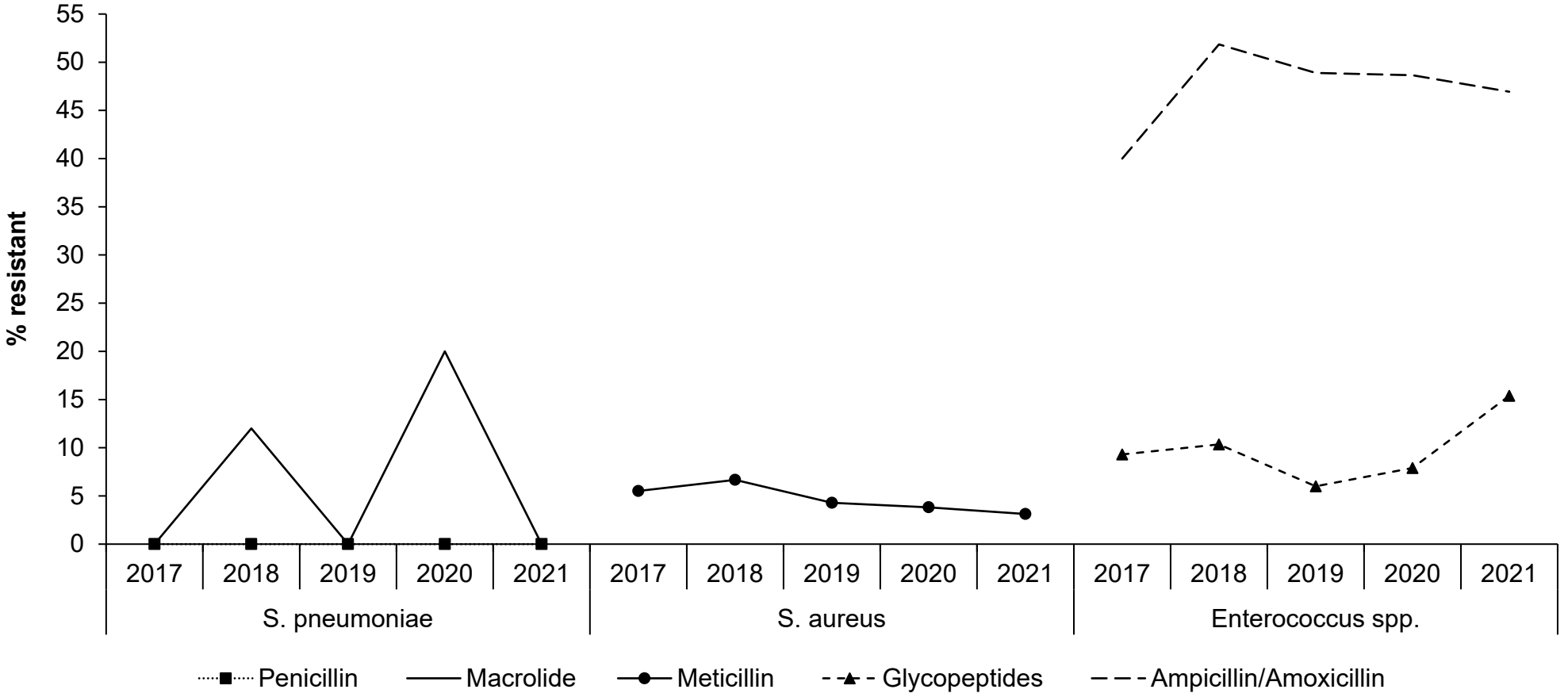
Figure 16. BSI rates per 100,000 children aged 12 to 17 years in England: 2017 to 2021. (a) Gram-positive bacteria (*S. aureus, S. pneumoniae* and *Enterococcus* spp.) (b) Gram-negative bacteria (*Acinetobacter* spp., *E. coli*, *K. pneumoniae* and *Pseudomonas* spp.)



6.2 AMR of Gram-positive BSI

There has been an increase in *Enterococcus* spp. resistance to glycopeptides between 2020 and 2021 (7.9% n=38 to 15.4% n=52) with resistance levels higher than those seen pre-pandemic (9.3% in 2017 n=43). Resistance of *S. aureus* to meticillin continued on a downwards trend since 2018 (2018: 6.7% n=135 to 2021: 3.1% n=128) (Figure 17).

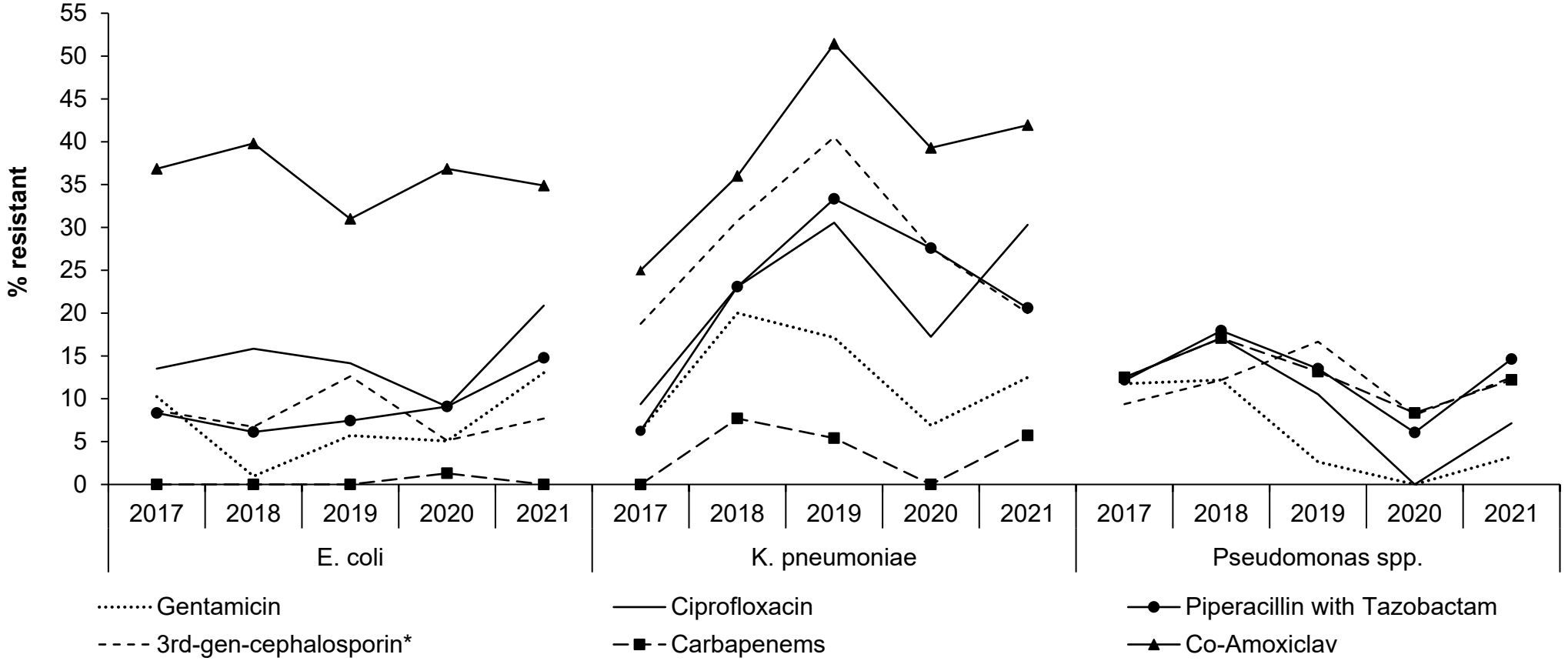
Figure 17. AMR of Gram-positive BSI in children aged 12 to 17 years, England, 2017 to 2021



6.3 AMR of Gram-negative BSI

Between 2020 and 2021, there was an increase in *E. coli* resistance to gentamicin (5.1% n=79 to 13.0% n=92), ciprofloxacin (9.1% n=77 to 20.9% n=91), piperacillin with tazobactam (9.1% n=77 to 14.8% n=88), and third-generation cephalosporins (5.1% n=78 to 7.7% n=91). Between 2020 and 2021, resistance of *K. pneumoniae* to gentamicin (6.9% n=29 to 12.5% n=32), ciprofloxacin (17.2% n=29 to 30.3% n=33), carbapenems (0% n=29 to 5.7% n=25) and co-amoxiclav (39.3% n=28 to 41.9% n=31) all increased (Figure 18).

Figure 18. AMR of Gram-negative BSI in children aged 12 to 17 years, England, 2017 to 2021



* Third-generation cephalosporins: cefotaxime, ceftazidime, ceftriaxone or cefpodoxime; except for *Pseudomonas* spp. where only ceftazidime is looked at.

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2. Office for National Statistics (ONS) Mid-year population estimates for England, Wales and Northern Ireland
3. UKHSA Antimicrobial Resistance and Healthcare Associated Infections (AMRHAI) Reference Unit

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