BJMS
www.batnajms.net

Batna Journal of Medical Sciences 2026;13(8):09
https://doi.org/10.48087/BJMS.2026.130809

ORIGINAL ARTICLE

Streptococcus pneumoniae carriage in children less than 25 months in the north of Algeria (Blida) after the introduction of PCV13

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ABSTRACT

In Algeria, the 13-valent pneumococcal conjugate vaccine (PCV13) was introduced into the national immunisation programme in 2016. This study aimed to determine the nasopharyngeal carriage rate of *Streptococcus pneumoniae*, antimicrobial resistance patterns, and serotype distribution among healthy children under 25 months of age. Nasopharyngeal samples were collected between February and May 2024, and a total of 508 children were enrolled. Isolates were identified using conventional microbiological methods and confirmed by matrix-assisted laser desorption/ionisation time-of-flight mass spectrometry (MALDI-TOF MS). Antimicrobial susceptibility testing (AST) was performed according to the Clinical and Laboratory Standards Institute (CLSI) guidelines, and serotyping was carried out using latex agglutination and the Quellung reaction. The nasopharyngeal carriage rate of *S. pneumoniae* was 15.9% (81/508), with 76.5% (62/81) of isolates showing reduced susceptibility to penicillin. Resistance rates to amoxicillin, erythromycin, and co-trimoxazole were 22.2% (18/81), 54.3% (44/81), and 29.6% (24/81), respectively. Serotyping was performed on 42 penicillin-non-susceptible pneumococcal (PNSP) isolates. Vaccine serotypes accounted for 19.1% (8/42) of isolates and included serotypes 7F, 3, 19A, 19F, 6A, and 6B, whereas non-vaccine serotypes represented 80.9% (34/42) and included serotypes 15B, 23A, 17F, 11A, and 29. Compared with the findings of a similar study conducted in the same region ten years earlier, the proportion of vaccine serotypes among PNSP isolates decreased significantly from 67.4% (29/43) in 2014 to 19.1% (8/42) in 2024 ($p < 0.001$).

Keywords: *S. pneumoniae*, nasopharyngeal carriage, serotypes, Algeria, PCV13.

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Received: 01 May 2026
Accepted: 15 Jul 2026

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1. INTRODUCTION

Pneumococcal carriage in the upper respiratory tract is a dynamic process that evolves over time and is influenced by multiple factors [1]. It is most prevalent in children (20-70%), with carriage rates peaking during the first two years of life, making them the primary reservoir and source of transmission [2]. *Streptococcus pneumoniae* can cause diseases ranging from non-invasive infections, such as otitis media and sinusitis, to more severe invasive pneumococcal diseases (IPDs), including meningitis and bacteremia [3].

To reduce the burden of pneumococcal disease, pneumococcal conjugate vaccines (PCVs) were developed and have proven effective in preventing invasive infections caused by vaccine-included serotypes. Vaccination has significantly decreased both the incidence of pneumococcal infections and the prevalence of nasopharyngeal carriage of vaccine serotypes in immunized children.

In Algeria, the 13-valent pneumococcal conjugate vaccine (PCV13) was introduced into the national immunization programme (NIP) in 2016, following a 3-dose schedule administered at 2, 4, and 12 months of age. According to World Health Organization and United Nations International Children's Emergency Fund (WHO/UNICEF) estimates, national PCV13 vaccination coverage was 90% in 2024 [4].

The aim of this study was to estimate the carriage frequency, the antimicrobial resistance frequency, and the serotype distribution *of S. pneumoniae* in children under 25 months of age.

2. MATERIALS AND METHODS

This prospective study was conducted from February to May 2024 on nasopharyngeal samples collected using cotton swabs from healthy children under 25 months of age. The children included were those who attended health centres for vaccination, preceded by a medical consultation. All parents were informed and gave their consent. Samples were sent to Institut Pasteur of Algeria and cultured on blood agar; identification of the alpha-hemolytic colonies was performed by conventional techniques: bile solubility test using sodium deoxycholate, susceptibility to optochin, and confirmed by mass spectrometry MALDI-TOF.

Serotyping was performed by latex agglutination and Quellung reaction, which represents the reference technique [5]. In our study, we focused on penicillin-non-susceptible (PNSP) due to the issue of antibiotic resistance. These strains are more frequently associated with treatment failure and the spread of resistant serotypes. Antibiotic susceptibility testing was performed according to the recommendations of the Clinical and Laboratory Standards Institute (CLSI) [6] by determining the minimal inhibitory concentrations (MIC) of penicillin and amoxicillin and by performing disk diffusion tests for erythromycin and co-trimoxazole. Percentages were compared using the chi-square (χ^2) test.

3. RESULTS

A total of 508 children meeting the inclusion criteria, namely, being in good health, under 25 months of age, and residing in the Blida region, were enrolled in the study. The percentage of boys was 49.6% compared to 50.4% for girls. The participants had a mean age of 8.27 months. Of the population studied, 23.03% (n = 117) had not received any dose of PCV, while 76.97% had been vaccinated with at least one dose. Vaccinated children were distributed as follows: 24.21% (n = 123) were fully vaccinated (3 doses); 28.94% (n = 147) had received a single dose of PCV, and 23.82% (n = 121) had received two doses. In this study, "fully vaccinated" was defined as children who had received the 3 doses of vaccination schedule; therefore, the proportion of fully vaccinated children should not be interpreted as national vaccination coverage, because not all infants had reached the age required to complete the schedule.

The carriage rate of *S. pneumoniae* is 15.94% (81/508). Among the carriers, only 25.93% had received a full 3-dose vaccination. The proportion of carriers correctly vaccinated for their age was 92.6%. All *S. pneumoniae* isolates exhibited the following characteristics: 76.5% had reduced penicillin susceptibility (MIC ≥ 0.125 µg/ml); resistance rates to amoxicillin, erythromycin, and cotrimoxazole were 22.2%, 54.3%, and 29.6%, respectively. The MIC distribution for penicillin and amoxicillin is shown in figure 1.

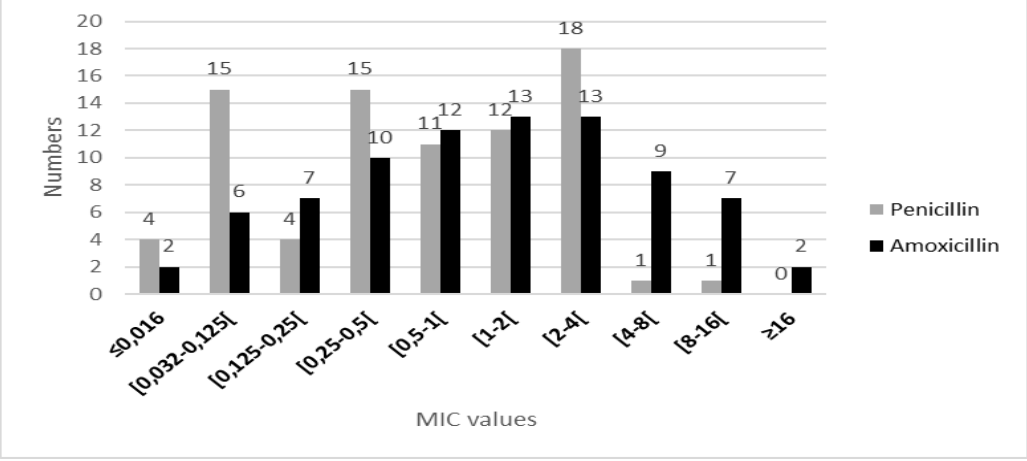

Figure 1. MIC (mg/l) distribution of penicillin and amoxicillin (N=81).

Serotyping was conducted on 42 PNSP isolates. The frequency of vaccine serotypes was 19.1%, including serotype 7F, which represented 7.14%, and serotypes 3, 19A, 19F, 6A, and 6B, each of which represented 2.38%. Non-vaccine serotypes represented 80.9%. Themost frequent non-vaccines serotypes were 15B, 23A, 17F, 11A, and 29, with rates of 14.3% (6/42) for each of serotypes 15B and 23A and 7.14% (3/42) for each of serotypes 17F, 11A, and 29. Figures 2 and 3 show the global distribution of serotypes and their distribution by vaccination status. Looking at the distribution of serotypes by vaccination status reveals that fully vaccinated children are only carriers of non-vaccine serotypes.

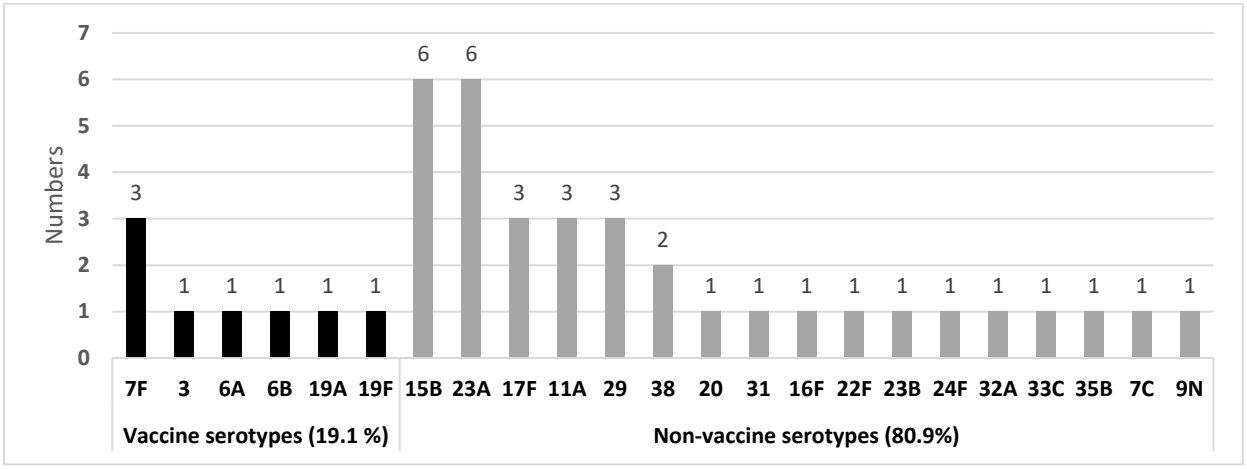

Figure 2. Global serotypes distribution of reduced penicillin susceptibility isolates (N=42).

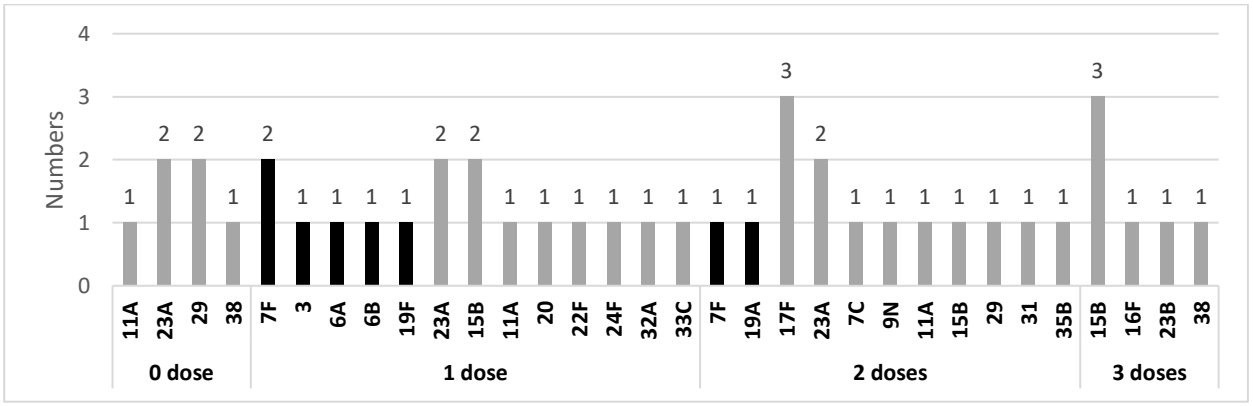

Figure 3. Serotypes distribution of reduced penicillin susceptibility isolates by vaccinal status (N=42).

4. DISCUSSION

In comparison with the findings of the 2014 study prior to the introduction of the PCV13[7], the carriage frequency decreased from 20% to 15.94%, and the frequency of vaccine serotypes among PNSP decreased significantly ($p<0.001$) from 67.4% in 2014 to 19.1% in 2024.

In 2014, the vaccine serotypes described among PNSP isolates were 19F, 14, 23F, 19A, 6B, and 6A, while the non-vaccine serotypes identified were 29, 15B, 15A, 6C, 23B, 35B, and 9N. The serotypes 15A and 6C, which were reported in 2014, were not identified in our study. Table 1 compares the results obtained in the two studies. A 32% carriage rate was reported in a 2012 study in Algiers [8].

Table1. Pneumococcal carriage surveys, comparison between 2014 and 2024 in Blida region.

	2014 [7]	2024 (Our Study)	χ^2 Test
Study population size	335	508	
Average age	9.5 months	8.27 months	
Carriage rate	20% (67/335)	15.9% (81/508)	p=0,1
PNSP vaccine serotypes	67.4% (29/43)	19.1% (8/42)	p<0.001
PNSP non-vaccine Serotypes	32.6% (14/43)	80.9% (34/42)	p<0.001
Reduced penicillin susceptibility isolates rate	64% (43/67)	76.5% (62/81)	p=0.1

Pneumococcal carriage rates vary between countries and study periods. Comparing our results with those from neighboring and other countries, a higher carriage rate of 43.3% was reported in Morocco between 2017 and 2018, five years after the introduction of PCV10, representing an estimated decline of 86% [9]. In Morocco, PCV10 was introduced into the NIP in 2012 on a 2 + 1 schedule. Before this, the NIP had used PCV13, which was reintroduced in 2023.

In Tunisia, a rate of 24.4% was observed between 2020 and 2022, after the introduction of PCV10 in 2019, which is close to the rate recorded in our country. In Tunisia, PCV10 was introduced into the NIP in 2019, with a 2 + 1 schedule. Prior to this, PCV7, PCV10, and PCV13 were only available in the private secto r[10]. In Egypt, where pneumococcal conjugate vaccines are not included in the national immunization programme, the carriage rate was 30% in 2014 [11]. In Peru, a post-PCV13 carriage rate of 20.8% was reported in 2019 [12]. Turkey recorded a substantial reduction in carriage three years after the introduction of PCV13, with a rate of 9.8% in 2014 compared to 21.9% three years after the implementation of PCV7 [13].

The rate of PNSP in our study was 76.5%. This rate is higher than that recorded in 2014 (64%) in children from the same region [7]. These results are close to those obtained in Peru: from 60.4% in 2008 to 74.5% in 2019 [12]. In our study, resistance to other antibiotics was 22.2% for amoxicillin, 54.3% for erythromycin, and 29.6% for cotrimoxazole. In the study conducted in Algiers in 2012, the rate of resistance was 48% for erythromycin and 40.2% for cotrimoxazole [8]. In the 2014 study, resistance was 3%, 50%, and 24% for amoxicillin, erythromycin, and cotrimoxazole, respectively [7].

Although our monocentric study provides valuable preliminary data, further multicenter studies are required to strengthen the evidence and support these findings.

5. CONCLUSION

To the best of our knowledge, based on a comprehensive literature review, this is the first published pneumococcal carriage study conducted in our country in the post-PCV13 era. This study, carried out eight years after the introduction of PCV13, demonstrated the impact of vaccination on circulating serotypes, with a reduction in the carriage of vaccine serotypes. The emergence of non-vaccine serotypes requires the establishment of a multicenter surveillance system to monitor the serotypes circulating in our country.

Acknowledgements: Staff of Institute Pasteur of Algeria - Algiers (Algeria)

Competing interests: The authors declare that they have no competing interest.

Funding: This research was funded by Institut Pasteur d'Algérie.

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