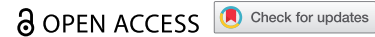


REVIEW



Pneumococcal vaccination offer and schedules in adults in EU countries: An update

Manuela Chiavarini*, Sara Boccalini*, Angela Bechini , Alisa Barash, Enrica Castellana, Alessandro Senape, and Paolo Bonanni

Department of Health Sciences, University of Florence, Florence, Italy

ABSTRACT

Streptococcus pneumoniae is a major cause of illness and death among both young and older populations in Europe. Although all EU countries have established childhood vaccination programs, adult vaccination policies vary widely. This study analyzed pneumococcal vaccination strategies for adults across the 27 EU member states, using data collected up to December 2024 from official sources such as ECDC, WHO, and national health websites. Data were compiled and independently reviewed by two researchers, with final validation by a senior expert. Results indicate that 23 countries (85.2%) have implemented adult vaccination programs. However, substantial differences exist regarding vaccine types, targeted groups, and the extent of recommendation or obligation. Vaccination is advised for healthy adults aged 65 years and older in 21 countries and for at-risk individuals in 17. While 21 countries recommend it, 6 do not provide public funding. These discrepancies highlight the need for harmonized and more comprehensive adult vaccination strategies in Europe.

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Introduction

Streptococcus pneumoniae (SP), pneumococcus, is a significant cause of morbidity and mortality in younger and older populations worldwide. Particularly, pneumococcal diseases are a frequent cause of hospitalization and death for older adults in Europe.¹ In 2022, the European Union and European Economic Area (EU/EEA) reported 17,700 confirmed cases of invasive pneumococcal disease (IPD), corresponding to a crude notification rate of 5.1 cases per 100,000 population and the incidence rates observed in adults aged 65 years and older are 12.6 cases per 100,000.¹ In addition to IPD, community-acquired pneumonia (CAP) remains a significant public health concern among adults, particularly the elderly.²

Many countries in the southern and eastern parts of the EU have low notification rates. A seasonal pattern and different incidence across EU countries are evident.² This difference underscores the need for targeted prevention efforts tailored to specific regional epidemiology particularly in addressing CAP and other pneumococcal diseases among high-risk populations.²

Vaccination is the most effective strategy to prevent pneumococcal disease and their complications.³ Pediatric immunization programs have been implemented across Europe, leading to reduced disease incidence in children and providing indirect protection to adults.³

While all European countries implement vaccination programs for children, there are gaps and differences in terms of vaccination programs for adults.⁴

Streptococcus pneumoniae colonization in the upper respiratory tract is less prevalent in adults than in children but still plays a crucial role in transmission and disease development.⁵ Notably, the serotypes responsible for most invasive pneumococcal diseases in adults are rarely found in carrier children, indicating that herd protection derived from infant PCV13 vaccination may be limited.⁶ This underscores the need for targeted vaccination programs specifically designed for adults to enhance protection against pneumococcal disease. However, despite vaccination efforts, pneumococcal disease remains a significant public

CONTACT Angela Bechini  angela.bechini@unifi.it  Department of Health Sciences, University of Florence, Florence 50134, Italy.

*Contributed equally to the manuscript.

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health concern, particularly among vulnerable populations such as the elderly and individuals with underlying chronic conditions highlighting the ongoing need for comprehensive prevention strategies.⁷ This ongoing challenge highlights the importance of vaccination strategies tailored to these high-risk groups. Differences in the introduction and utilization of vaccines arise from recommendations provided by Health Technology Assessments (HTA) evaluations or by the National Technical Advisory Groups on Immunization (NITAGs) of the different EU countries. These multidisciplinary committees, appointed by individual countries, evaluate the potential benefits of integrating vaccines into the national immunization program (NIP)).⁸ Their assessment involves reviewing epidemiological data (such as incidence, prevalence, and unmet needs), analyzing health economic factors (including cost-effectiveness and budget impact analyses), and considering other relevant aspects ensuring that vulnerable populations receive appropriate protection.⁸ This study provides a review of pneumococcal vaccination policies for adults in Europe, analyzing vaccination recommendations in different European countries.

Materials and methods

A comprehensive search for documents and data on *Streptococcus pneumoniae* vaccination policies and strategies across the 27 EU member states was conducted up to December 2024.

This search was conducted using the ECDC Vaccine Scheduler as a starting point,⁹ supplemented by an additional search for NIPs on other institutional websites, including the WHO, Ministries of Health, and National Institutes of Health, as well as relevant literature articles. The search terms were: (“*Streptococcus pneumoniae*”) AND ((immunization) OR (vaccination)). National immunization policies were investigated by reviewing relevant articles found through the specified database search terms, as well as through Google searches for government and health organization recommendations. Two researchers independently conducted the search. The relevant information on Immunization Schedules was compiled into an electronic database (Excel) for each European country and then summarized in a table with the following fields: country, recommendations in the NIP, vaccine authorized and in use, immunization schedules, age of vaccine administration, groups at risk, and funding. Each European country’s data sheet underwent a double-check by two researchers, followed by a further review by a senior researcher.

The data collected for each country have been compared to highlight similarities and differences in the available vaccines and NIP recommendations.

Results

Authorized and available pneumococcal vaccines

In Europe there are several pneumococcal vaccines available for adults, licensed by EMA, which open possibilities for a wide range of protocols, using different combinations of vaccines, that can be followed to achieve effective protection. A summary of the pneumococcal vaccination types available and their main characteristics, based on the European Centre for Disease Prevention and Control (ECDC) guidelines,¹ are reported in Table 1.

The pneumococcal vaccines approved at EU level for adults are: the 13-valent conjugate vaccine (PCV13) (Prevenar 13: <https://www.ema.europa.eu/en/medicines/human/EPAR/prevenar-13>), the 15-valent conjugate vaccine (PCV15) (Vaxneuvance: <https://www.ema.europa.eu/en/medicines/human/EPAR/vaxneuvance>), the 20-valent conjugate vaccine (PCV20) (Prevenar-20/Apexxnar: <https://www.ema.europa.eu/en/medicines/human/EPAR/prevenar-20>), and the 23-valent polysaccharide vaccine (PPSV23) (Pneumovax 23: <https://www.ema.europa.eu/en/medicines/human/EPAR/pneumovax-23>).

The first three vaccines are vaccines containing conjugated polysaccharide capsule antigens and they use CRM197 as a carrier which is a nontoxic mutant of diphtheria toxin and derived from *Corynebacterium diphtheriae* C7, expressed in recombinant form in *Pseudomonas fluorescens*; PPSV23 vaccine contains purified non-conjugated polysaccharide capsular antigens.

It is used in some protocols with a single dose after a course with a conjugate vaccine, increasing the response and giving wider protection for invasive disease and lung infection.^{9,10} PCV and PPSV vaccines are often used together to provide broader protection against pneumococcal infections, especially for high-risk

Table 1. Pneumococcal vaccines and vaccination available in the EU.

Vaccine Type	Description	Indication	Age Group	Dose schedule for adults	Available vaccines
Pneumococcal Conjugate Vaccine (PCV)	A conjugated vaccine (enhance the immune response) that links polysaccharide capsules from several pneumococcal serotypes to the CRM197 carrier protein and adsorbed onto aluminium phosphate	Prevents invasive pneumococcal disease and pneumonia caused by the serotypes included in the vaccine.	>6 weeks of age	A single dose for adults.	PCV20 (Prevenar 20), PCV15 (Vaxneuvance) PCV13 (Prevenar 13).
Pneumococcal Polysaccharide Vaccine (PPSV)	A vaccine that contained purified non-conjugated polysaccharide capsule antigens from several pneumococcal serotypes	Prevention of invasive disease and pneumonia infection.	Adults ≥50 years and from 2 years of age in high-risk individuals.	A single dose for adults; repeated dose in certain high-risk cases (e.g., immunocompromised)	PPSV23 (Pneumovax 23)

(Source: ECDC, EMA).

groups.^{1,9} This combined approach, known as Sequential pneumococcal vaccination (PCV + PPSV), is recommended for adults aged 50 and older, as well as for high-risk individuals from the age of 2 years.^{1,9} The number of doses – one or two – depends on a person's health condition and age.^{1,9} Although PCV vaccines and PPSV23 are not typically marketed as a single combined product, they are administered sequentially in certain cases to enhance immunity.^{1,9} The serotypes contained in the anti-pneumococcal vaccines are reported in [Table 2](#).

Pneumococcal vaccine schedules in EU countries

This section provides an overview of the current landscape of pneumococcal vaccination for adults in European countries, provides updated recommendations on vaccination schedules and types of vaccines used in different European Union (EU) countries (Table S1: Pneumococcal Vaccine schedules in EU countries). As shown in Figure 1, Pneumococcal vaccination programs for adults were implemented in 23 EU countries (85.2% of all 27 EU countries). They are fully integrated in the National Immunization Program in 21 EU countries (Austria, Belgium, Bulgaria, Cyprus, Czechia, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Poland Portugal, Slovakia, Slovenia, Spain and Sweden) and are included in vaccination programs or supported by institutional recommendations in two additional countries (Denmark, Latvia). The Danish Health Authority provides conditional subsidies for the purchase of vaccines to designated specific groups, including individuals aged 18 years and older who are considered at risk, as well as all individuals aged 65 years and above (<https://www.sst.dk/da/viden/Forebyggelse/Vaccination/Vaccination-af-voksne/Tilskud-til-vacciner>; <https://www.sst.dk/da/Fagperson/Forebyggelse-og-tvaergaende-indsatser/Vaccination/Vaccination-af-voksne/Tilskud-til-vacciner>). Similarly, the national health authorities of Latvia recommend the PCV20 vaccine for individuals aged 18 years and older who belong to at-risk groups, as well as for all individuals aged 65 years and above (<https://www.vmnvd.gov.lv/en/health-care-latvia>; www.spkc.gov.lv/lv/media/17357/download). Among the 21 EU countries where pneumococcal vaccination is fully integrated into the NIP, there are six countries (Austria, Belgium, Bulgaria, Hungary, Poland, and Slovenia) where the vaccination is not funded by the National Health System. Pneumococcal vaccination is generally recommended by the national health authorities for healthy adults aged 65 years and older in 21 out of 23 countries (91.3%), or for those classified as at risk in 17 out of 23 countries (73.9%) (Figure 1).

Pneumococcal vaccination schedule stratified by age group and at-risk population are shown in Table S1 and [Figure 2](#).

Table 2. Comparison between serotypes of anti-pneumococcal vaccines.

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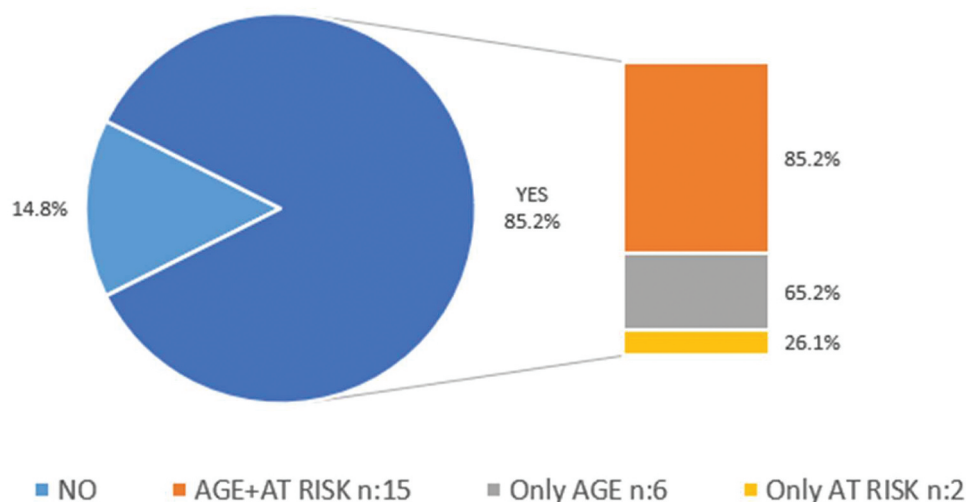


Figure 1. Pneumococcal vaccination programs for adults in EU countries.

The distribution of pneumococcal vaccines recommended for adult use across EU countries varies considerably. Specifically, 26.9% of EU member states recommend the use of the 23-valent pneumococcal polysaccharide vaccine (PPSV23) alone (Cyprus, Czechia, Denmark, Ireland, the Netherlands, Portugal, Spain). An equivalent proportion (26.9%) endorse a sequential vaccination strategy involving a pneumococcal conjugate vaccine (PCV) followed by PPSV23 (Austria, Bulgaria, Czechia, Estonia, Italy, Slovenia, Spain). PCV alone was used in 46.2% of EU countries, with PCV20 accounting for 66.7% of these (Belgium, Denmark, France, Germany, Greece, Hungary, Luxembourg, Sweden), PCV13 for 8.3% (Finland), and an unspecified PCV for 25.0%. (Latvia, Poland, Slovakia). Notably, some countries, such as Czechia, Denmark and Spain, implement multiple vaccination strategies depending on risk groups or other public health criteria, thereby employing more than one type of pneumococcal vaccine in adult populations. However, significant variations were observed across countries regarding the type of vaccine used, target populations, and approaches to implementation (Table S1 and Figure 3). Among the 21

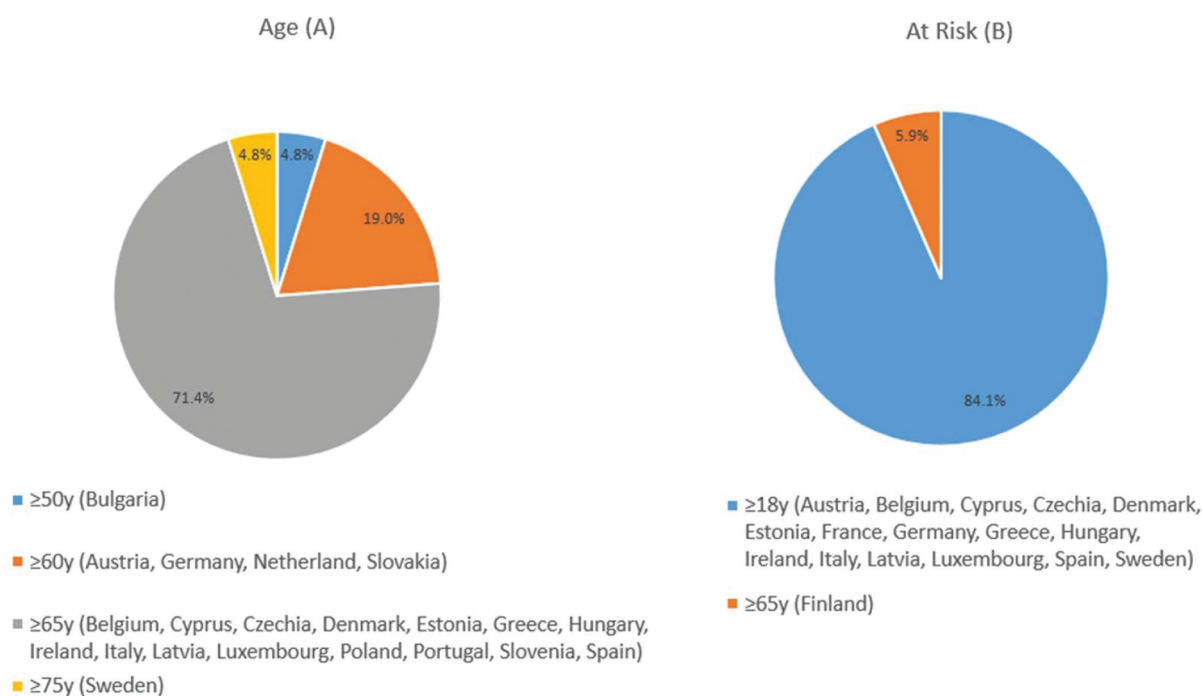


Figure 2. Pneumococcal vaccination for adults in EU countries, by age (A) and at-risk population (B).

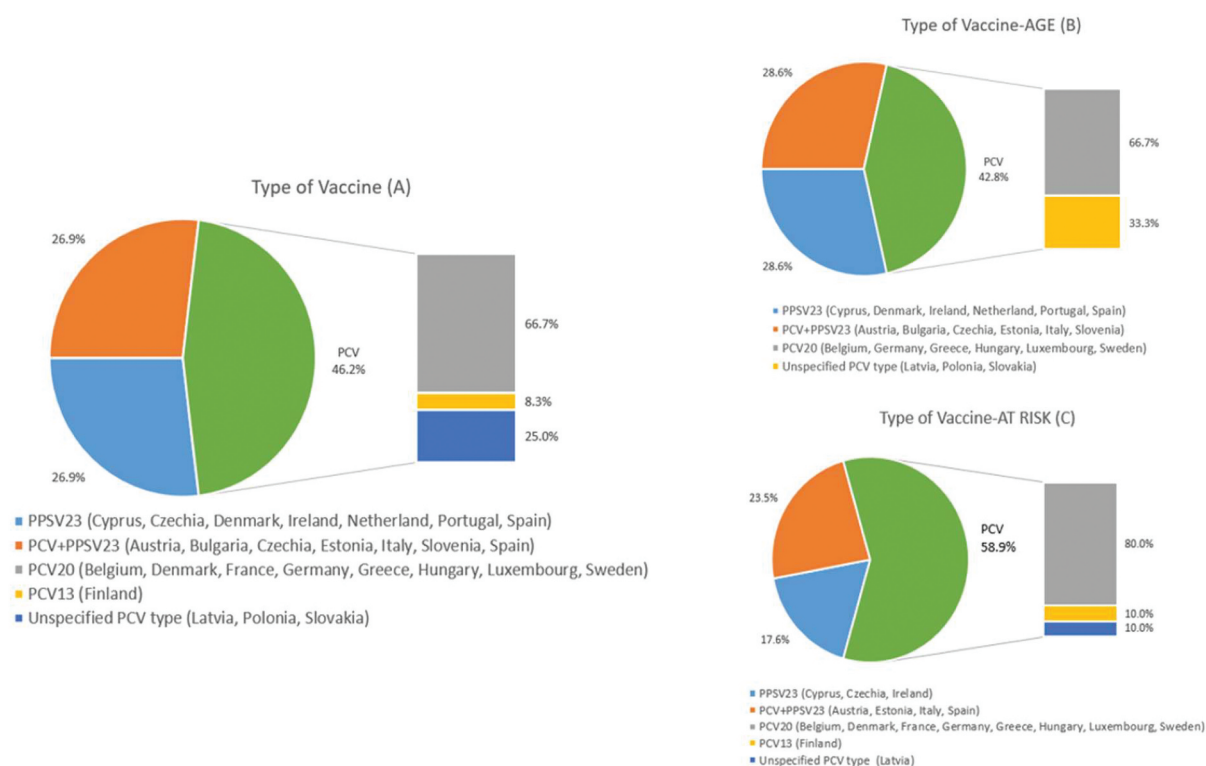


Figure 3. Distribution of the pneumococcal vaccines in adults in EU countries (A), analyzed by age (B) and at-risk population (C).

countries that have issued official recommendations for PCV vaccination by age group, out of the 23 where PCV vaccination program for adults is available, PPSV23 was administered in 28.6% of cases, while the sequential vaccination of a PCV vaccine followed by a dose of PPSV23 vaccine was used in an additional 28.6%. PCV alone was the most commonly used, accounting for 42.8% of cases; within this group PCV20 represented 66.7% and an unspecified PCV accounted for the remaining 33.3%.

Among the 17 countries that have issued official at-risk populations specific recommendations for PCV vaccination, out of the 23 where an adult PCV vaccination program is in place, PPSV23 was administered in 17.6% of cases, and the sequential vaccination of PCV followed by PPSV23 was used in 23.5%. PCV alone was the most widely used approach, accounting for 58.9% of cases, with PCV20 comprising 80.0%, PCV13 representing 10.0%, and an unspecified PCV making up the remaining 10.0%.

Discussion

In the past, vaccinations were primarily viewed as a way to prevent infectious diseases in children, aiming to protect them from various illnesses.³ However, the global epidemiological landscape has shifted, and it is now clear that individuals of all ages, including adults and the elderly, are at risk of serious complications from infectious diseases, especially those with chronic conditions.^{1,2} This shift has brought increased attention to the importance of adult vaccinations as part of public health efforts.

To address this need, a multi-disciplinary board of experts called the Adult Immunization Board (AIB) was established providing evidence-based guidelines for the implementation and optimization of adult immunization across Europe.¹¹ This initiative seeks to improve the management of vaccinations for adults, an area that has historically been overlooked compared to other immunization and highlights the growing recognition of adult immunization as a key component of public health strategies.¹¹ Vaccines for adults are essential not only for individual protection but also for reducing the spread of diseases to more vulnerable populations. Current vaccination initiatives primarily target high-risk adults, emphasizing the importance of lifelong immunization as a preventative health measure. Research from organizations such as the World

Health Organization (WHO) and the European Centers for Disease Control and Prevention (ECDC) underscores the value of adult vaccinations, particularly for diseases like pneumococcal infections, in older adults and individuals with chronic conditions.^{12,13}

Coordinated vaccination strategies across various age groups are needed at European level, with a particular emphasis on adult vaccination, especially among elderly individuals and those at high risk.^{8,14} Additionally, ongoing research into vaccine effectiveness in diverse populations could play a role in shaping national vaccination policies.^{9,14}

As a matter of fact, vaccines have become a critical component of public health, helping to reduce the incidence of preventable diseases and protect individuals of all ages from infectious threats. However, it is worth noting that not all European countries have included pneumococcal vaccination into their National Immunization Programs, nor have all provided institutional recommendations.⁹ While the global benefits of vaccination are widely acknowledged, it remains a crucial protective tool for both individuals and communities, helping to reduce complications and alleviate the burden of healthcare assistance (such as hospitalizations, outpatient visits, and the need for medications) for both families and society. Despite this, in many European countries the vaccination is still not offered and introduced into the NIP though data from several nations show that government-funded vaccination programs have led to higher vaccination uptake.⁹

Our results confirm, as found in 2019 by Cassimos et al.⁴ there is significant variability in recommendations for adults and the types of vaccines used across Europe. Despite the diversity of vaccination programs, it is evident that all countries implementing these programs adhere to the same core principles, recommending vaccination for adults aged 60/65 years and older, as well as for individuals considered at risk. In age-based guidelines, vaccination is mostly recommended for adults aged over the age of 60/65 years, with Belgium reporting an upper age limit of 85 years for vaccination.

In populations with chronic health conditions, there is substantial heterogeneity across EU countries regarding the type of pneumococcal vaccine administered, sequential strategies, and use of booster doses. This variability is further compounded by the lack of a standardized definition of “at-risk” populations. Each country applies different clinical and epidemiological criteria to identify individuals considered at increased risk for pneumococcal disease, resulting in divergent vaccination recommendations. For example, while some national immunization plans include conditions such as chronic liver disease, diabetes, or immunosuppressive therapy, others may not classify these as indications for vaccination. This inconsistency poses challenges for harmonizing public health strategies and ensuring equitable protection across the EU. Notably, asplenia – either anatomical or functional – represents the only comorbidity for which pneumococcal vaccination is uniformly recommended in all EU member states, underscoring a rare point of consensus in otherwise diverse national approaches. These marked differences in pneumococcal vaccination guidelines highlight the pressing need for harmonized recommendations at the European level to ensure more consistent and effective prevention of pneumococcal disease. The pneumococcal conjugate vaccine (PCV) is the most commonly used vaccine for adults aged 65 years or older, as well as for adults aged 19 to 64 years with underlying medical conditions or other risk factors, particularly those who have not previously received a pneumococcal conjugate vaccine or whose vaccination history is unknown. Despite clinical guidelines supporting enhanced protection through sequential vaccination – starting with a dose of PCV followed by the 23-valent pneumococcal polysaccharide vaccine (PPSV23)^{1,9} – only seven EU countries currently implemented this approach. This sequential strategy is particularly recommended for immunocompromised individuals and those with high-risk conditions, as it broadens serotype coverage and may improve long-term immunogenicity.⁹ The introduction of pneumococcal conjugate vaccines into national immunization plans has significantly contributed to the reduction of the incidence of invasive pneumococcal disease across various populations. The use of multivalent formulations, such as PCV 13, PCV15 and PCV20 has been pivotal in decreasing the overall disease burden. The adoption of higher-valent vaccines is intended to expand protection by covering a broader range of pneumococcal serotypes, thereby enhancing the effectiveness of vaccination programs.¹⁵

Countries have tailored their vaccination programs to address specific epidemiological needs; for example, Finland has adopted to administer the PPSV23 vaccine to individuals aged 75 years old and older (<https://thl.fi/fi/web/infektiotaudit-ja-rokotukset/rokotteet-a-o/pneumokokkirokotteet>).

In the European Union, immunization schedules have evolved over time in response to the changing epidemiology of pneumococcal disease and the emergence of new serotypes. Different EU countries have implemented distinct vaccination policies, shaped by national public health priorities, demographic profiles, and the availability of healthcare resources. Variations in healthcare systems and strategic approaches have significantly influenced national decisions regarding target populations for pneumococcal vaccination.¹⁰

However, the value of vaccination extends beyond improving individual health among the elderly; it also plays a key role in reducing healthcare costs and enhancing overall quality of life. This underscores the importance of establishing common public health policies aimed at optimizing both individual and population-level health outcomes.¹⁶

Routine adult vaccination programs should be strengthened, with particular emphasis on high-risk groups, including older adults and individuals with chronic conditions or other underlying vulnerabilities.¹⁷

Pneumococcal vaccination strategies for older adults must account for the indirect effects of childhood PCV programs, particularly for the herd immunity effect. Sustained monitoring and continuous surveillance of invasive pneumococcal disease epidemiology is essential, including the emergence of non-vaccine serotypes.¹⁸

The future of pneumococcal vaccination lies in the development and implementation of higher-valent PCVs with broader serotype coverage. This advancement underscores the need for harmonized guidelines across Europe to enhance the prevention and control of pneumococcal disease.¹⁹

This review has several limitations, including lack of available data on vaccine coverage (VC) rates in most European countries, which prevents meaningful comparisons between VC rates and national vaccination policies.^{20–22}

The search process was partially influenced by the navigability of government websites in each country. Additionally, language and translation challenges limited the review team's ability to assess institutional websites in their original languages, a limitation compounded by the inconsistent accuracy of automated translation tools such as Google Translate.

In conclusion, there are considerable disparities in the offer and schedules of pneumococcal vaccination within adult vaccination programs across Europe. Strengthening routine vaccination programs for adults is essential. By adopting common strategies and protocols, no country or region should fall behind in protecting its population from preventable diseases. EU member states can work together to establish a more cohesive and effective approach to address the public health challenges posed by pneumococcal infections.

Author contributions

CRediT: **Manuela Chiavarini:** Conceptualization, Methodology, Supervision, Writing – original draft; **Sara Boccalini:** Conceptualization, Methodology, Project administration, Supervision, Writing – original draft; **Angela Bechini:** Conceptualization, Methodology, Project administration, Validation, Writing – review & editing; **Alisa Barash:** Data curation, Formal analysis, Methodology; **Enrica Castellana:** Data curation, Formal analysis, Methodology; **Alessandro Senape:** Data curation, Formal analysis, Methodology; **Paolo Bonanni:** Conceptualization, Methodology, Project administration, Validation, Writing – review & editing.

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Notes on contributor

Angela Bechini graduated in Biological Sciences and earned PhD in Clinical and Preventive Pediatrics. Previously a researcher at the University of Florence. Since July 1, 2018, she has been Associate Professor of General and Applied Hygiene (scientific sector MED/42). Currently, she teaches in the degree courses in Medicine and Surgery, Dentistry

and Dental Prosthetics, Healthcare Assistance, and Biology. Her research focuses on the prevention of infectious diseases and the evaluation of vaccination strategies through seroepidemiological studies, analyzing antibodies to measles, mumps, rubella, varicella, pertussis, hepatitis A and B, and tetanus. She has participated as a speaker in over 100 national and international conferences and has contributed as first author or coauthor to more than 75 publications in international scientific journals.

ORCID

Angela Bechini  <http://orcid.org/0000-0002-6013-8779>

Ethical commitment

Not applied for review. The study did not require ethical approval as no human or animal subjects were involved.

References

1. European Centre for Disease Prevention and Control. Invasive pneumococcal disease – Annual Epidemiological Report for 2022. 2025. <https://www.ecdc.europa.eu/en/invasive-pneumococcal-disease>.
2. Navarro-Torné A, Montuori EA, Kossyvakis V, Méndez C. Burden of pneumococcal disease among adults in Southern Europe (Spain, Portugal, Italy, and Greece): a systematic review and meta-analysis. *Hum Vaccin Immunother*. 2021;17(10):3670–3686. doi: 10.1080/21645515.2021.1923348. PMID: 34106040; PMCID: PMC8437551.
3. Musher DM, Anderson R, Feldman C. The remarkable history of pneumococcal vaccination: an ongoing challenge. *Pneumonia (Nathan)*. 2022;14(1):5. doi: 10.1186/s41479-022-00097-y. PMID: 36153636; PMCID: PMC9509586.
4. Cassimos DC, Effraimidou E, Medic S, Konstantinidis T, Theodoridou M, Maltezou HC. Vaccination programs for adults in Europe, 2019. *Vaccine (Basel)*. 2020;8(1):34. doi: 10.3390/vaccines8010034. PMID: 31968652; PMCID: PMC7157239.
5. Arguedas A, Trzciński K, O'Brien KL, Ferreira DM, Wyllie AL, Weinberger D, Danon L, Pelton SI, Azzari C, Hammitt LL, et al. Upper respiratory tract colonization with *Streptococcus pneumoniae* in adults. *Expert Rev Vaccines*. 2020 ;19(4):353–366. doi: 10.1080/14760584.2020.1750378. PMID: 32237926.
6. Azzari C, Cortimiglia M, Nieddu F, Moriondo M, Indolfi G, Mattei R, Zuliani M, Adriani B, Degl'innocenti R, Consales G, et al. Pneumococcal serotype distribution in adults with invasive disease and in carrier children in Italy: should we expect herd protection of adults through infants' vaccination? *Hum Vaccin Immunother*. 2016;12(2):344–350. doi: 10.1080/21645515.2015.1102811. PMID: 26647277; PMCID: PMC5049737.
7. Teixeira R, Kossyvakis V, Galvez P, Méndez C. Pneumococcal serotype evolution and burden in European adults in the last decade: a systematic review. *Microorganisms*. 2023;11(6):1376. doi: 10.3390/microorganisms11061376. PMID: 37374878; PMCID: PMC10303156.
8. Martinelli D, Quattrone F, Fortunato F, Di Maggio E, Filia A, Rota MC, Lopalco PL, Prato R. Role of the National Immunisation Technical Advisory Groups in 13 European countries in the decision-making process on vaccine recommendations. *Euro Surveill*. 2023;28(43):2300131. doi: 10.2807/1560-7917.ES.2023.28.43.2300131. PMID: 37883041; PMCID: PMC10604541.
9. European Centre for Disease Prevention and Control. Pneumococcal vaccination guidelines. 2025. <https://vaccine-schedule.ecdc.europa.eu/>.
10. Noharet-Koenig R, Lasota K, Faivre P, Langevin E. Evolution of pneumococcal vaccine recommendations and criteria for decision making in 5 Western European countries and the United States. *MDM Policy Pract*. 2023;8(1):23814683231174432. doi: 10.1177/23814683231174432. PMID: 37274614; PMCID: PMC10233586.
11. Pattyn J, Del Riccio M, Bechini A, Hendrickx G, Boccalini S, Van Damme P, Bonanni P. The Adult Immunization Board (AIB): a new platform to provide multidisciplinary guidelines for the implementation and optimization of adult immunization in Europe. *Vaccine*. 2024;42(1):1–3. doi: 10.1016/j.vaccine.2023.11.060. PMID: 38044243.
12. World Health Organization. Immunization, vaccines and biologicals. 2022. <https://www.who.int>.
13. Centers for Disease Control and Prevention. Adult immunization schedule. 2021. <https://www.cdc.gov>.
14. Tin Tin Htar M, Stuurman AL, Ferreira G, Alicino C, Bollaerts K, Paganino C, Reinert RR, Schmitt HJ, Trucchi C, Vestraeten T, et al. Effectiveness of pneumococcal vaccines in preventing pneumonia in adults, a systematic review and meta-analyses of observational studies. *PLOS ONE*. 2017;12(5):e0177985. doi: 10.1371/journal.pone.0177985. PMID: 28542347; PMCID: PMC5441633.
15. Micoli F, Romano MR, Carboni F, Adamo R, Berti F. Strengths and weaknesses of pneumococcal conjugate vaccines. *Glycoconj J*. 2023;40(2):135–148. doi: 10.1007/s10719-023-10100-3. Epub 2023 Jan 18; PMID: 36652051; PMCID: PMC10027807.

16. Esposito S, Franco E, Gavazzi G, de Miguel AG, Hardt R, Kassianos G, Bertrand I, Levant MC, Soubeyrand B, López Trigo JA. The public health value of vaccination for seniors in Europe. *Vaccine*. 2018;36(19):2523–2528. doi: [10.1016/j.vaccine.2018.03.053](https://doi.org/10.1016/j.vaccine.2018.03.053). PMID: 29615269.
17. Andreoni M, Sticchi L, Nozza S, Sarmati L, Gori A, Tavio M, Society for Infectious and Tropical Diseases (SIMIT). Recommendations of the Italian Society for Infectious and Tropical Diseases (SIMIT) for adult vaccinations. *Hum Vaccin Immunother*. 2021;17(11):4265–4282. doi: [10.1080/21645515.2021.1971473](https://doi.org/10.1080/21645515.2021.1971473). PMID: 34524945; PMCID: PMC8828129.
18. Hanquet G, Krizova P, Valentiner-Branth P, Ladhani SN, Nuorti JP, Lepoutre A, Mereckiene J, Knol M, Winje BA, Ciruela P, et al. Effect of childhood pneumococcal conjugate vaccination on invasive disease in older adults of 10 European countries: implications for adult vaccination. *Thorax*. 2019;74(5):473–482. doi: [10.1136/thoraxjnl-2018-211767](https://doi.org/10.1136/thoraxjnl-2018-211767). PMID: 30355641; PMCID: PMC6484683.
19. Bonnave C, Mertens D, Peetermans W, Cobbaert K, Ghesquiere B, Deschodt M, Flamaing J. Adult vaccination for pneumococcal disease: a comparison of the national guidelines in Europe. *Eur J Clin Microbiol Infect Dis*. 2019;38(4):785–791. doi: [10.1007/s10096-019-03485-3](https://doi.org/10.1007/s10096-019-03485-3). PMID: 30778705.
20. Janssens A, Vaes B, Abels C, Crèvecoeur J, Mamouris P, Merckx B, Libin P, Van Pottelbergh G, Neyens T. Pneumococcal vaccination coverage and adherence to recommended dosing schedules in adults: a repeated cross-sectional study of the INTEGRO morbidity registry. *BMC Pub Health*. 2023;23(1):1104. doi: [10.1186/s12889-023-15939-7](https://doi.org/10.1186/s12889-023-15939-7). PMID: 37286969; PMCID: PMC10245355.
21. Perniciaro S, van der Linden M. Pneumococcal vaccine uptake and vaccine effectiveness in older adults with invasive pneumococcal disease in Germany: a retrospective cohort study. *Lancet Reg Health Eur*. 2021;7:100126. doi: [10.1016/j.lanepe.2021.100126](https://doi.org/10.1016/j.lanepe.2021.100126). Erratum in: *Lancet Reg Health Eur*. 2022 May 29;18:100409. doi: [10.1016/j.lanepe.2022.100409](https://doi.org/10.1016/j.lanepe.2022.100409). PMID: 34557837; PMCID: PMC8454757.
22. International Longevity Centre UK: European pneumococcal vaccination: a progress report. ILC; 2023. <https://ilcuk.org.uk/european-pneumococcal-vaccination-a-progress-report/>.