HEALTH PROMOTION

Adolescent vaccination in Italy: bridging policy, clinical practice and public engagement to improve coverage

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Keywords

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Summary

Adolescence represents a pivotal phase for immunization, yet vaccine coverage in this population remains suboptimal across Italy, particularly against human papillomavirus (HPV) and meningococcal B (MenB), causing a high morbidity associated with HPV-related cancers and MenB-related invasive disease, respectively. Despite inclusion in national immunization strategies, wide regional disparities persist, partly driven by the fact that MenB vaccination is included in the National Vaccination Prevention Plan (PNPV) for infancy but not for adolescence, leaving its adolescent implementation to regional policies. Moreover, adolescents' transitional care phase, psychological perceptions of invulnerability, and structural barriers contribute to delayed or missed vaccinations. Drawing on recent epidemiological data, the paper examines the epidemiological, institutional, and sociobehavioral factors influencing uptake of key adolescent vaccines and highlights the clinical and public health urgency of strengthening the inclusion of adolescent vaccines within national and regional immunization plans, as a prerequisite for improving HPV and MenB vaccination coverage.

Current strategies, including the 2023–2025 National Vaccination Prevention Plan (PNPV), the "Calendar for Life" and regional best practices emphasize the need for harmonized national policies. Future directions include, among others, integrating MenB into the adolescent PNPV, enhancing vaccine delivery through settings – such as schools and sports medicine programs –, and adopting behavioral science frameworks, including the 5C model, to address vaccine hesitancy.

Nationally coordinated communication campaigns and digital registry systems are critical to ensuring equitable, timely, and comprehensive adolescent immunization.

Introduction

Adolescence is a pivotal developmental stage marked by increasing autonomy, identity formation, and greater social interaction, often accompanied by risk-taking behaviors that can undermine preventive health engagement [1, 2].

Vaccination during adolescence is not only crucial for individual health but also for community protection, given the high frequency of interpersonal interactions in school, sports, and social settings [3]. Despite a strong public health rationale, vaccine uptake among adolescents remains inconsistent, reflecting both systemic and psychosocial barriers. These include limited access to preventive services, inadequate integration of care during the transition from pediatric to adult healthcare providers, and structural issues in vaccine delivery [4, 5].

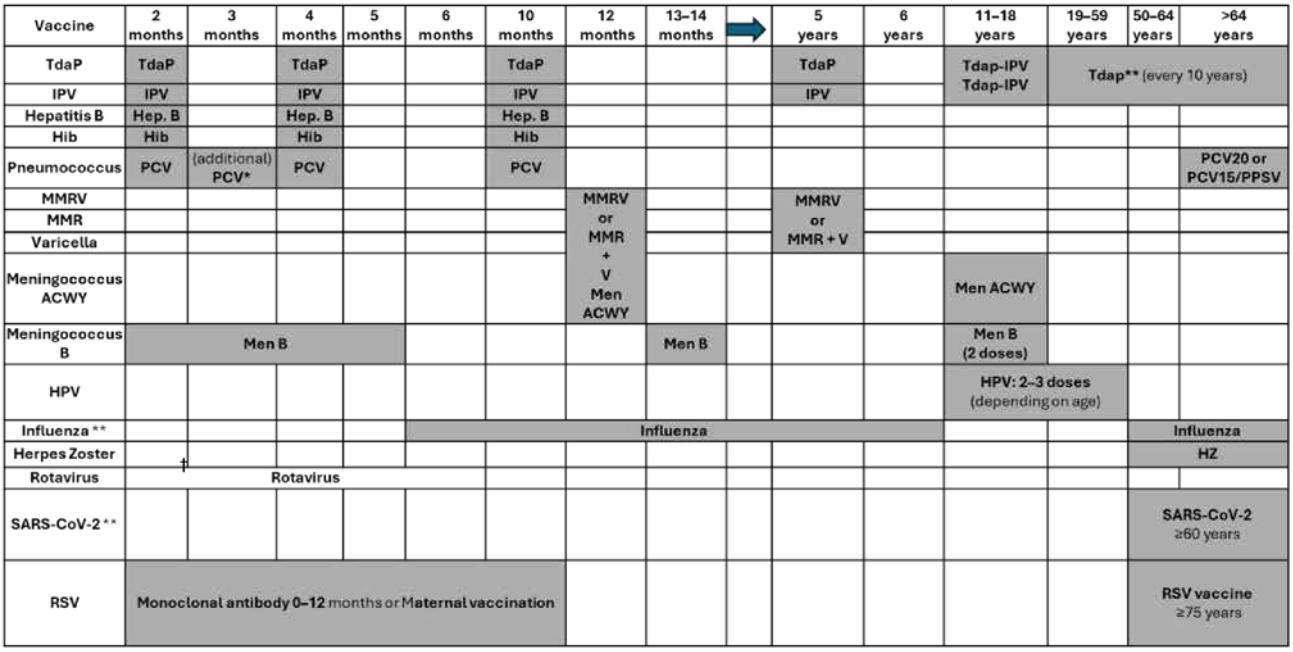
In addition, adolescent's decision-making is influenced by emotional and cognitive drivers, such as a preference for short-term outcomes and a reliance on peer and digital information sources, which may hinder vaccine acceptance [6, 7]. Schools, healthcare professionals, and families are thus essential in shaping attitudes and fostering informed health choices [8]. Strengthening adolescent immunization strategies requires a multifaceted approach, integrating evidence-based communication, supportive health policies, and equitable service delivery to ensure optimal coverage and long-term health outcomes.

Adolescents: a critical phase for immunization

The adolescent life stage presents a strategic opportunity for preventive health interventions, particularly immunization, which plays a dual role: completing primary series missed during childhood and introducing age-specific vaccines such as human papillomavirus (HPV), MenB, and MenACWY [3]. Additional scheduled vaccines in this age group include Tdap (tetanus, diphtheria, and pertussis), MMR (measles, mumps and rubella), varicella, and influenza, with particular attention to catch-up strategies post-COVID-19 disruptions (Fig. 1; Tab. I) [9, 10].

Adolescents are a major reservoir for the transmission of infectious diseases due to their frequent attendance at schools, clubs, and public gatherings [3]. The Delayed

Fig. 1. The Italian "Calendar for Life".



†For adolescents who have been already vaccinated as part of the universal active and free vaccination program in their first year of life (last dose administered within 24 months of age), a new cycle of two dose-schedule, either with the 4-component vaccine or with the 2-component vaccine, is recommended. For adolescents who have already received a cycle of 4-component vaccine (last dose received between 2-10 years of age), they can either receive 1 dose (or 2 doses, depending on regional choices) of the 4-component vaccine, or receive two doses of the 2-component vaccine. * In case of 3+1 PCV20 schedule. ** Vaccine strongly recommended during pregnancy. The calendar refers to vaccination programs aimed at the entire population; this schedule does not take into account the programs targeting at-risk groups or categories. Months and years are considered completed. Examples: the first dose of DTaP-IPV-HBV-Hib can be offered from 2 months of age, or from 61 days of life; the booster dose DTaP-IPV-HBV-Hib at 10 months, or from 301 days of life. Vaccines for which co-administration is strongly recommended are highlighted (yellow) [10].

Tab. I. Adolescent vaccination and booster recommendations according to the Calendar for Life.

Vaccine	Adolescent recommendation	Specific note for previously vaccinated individuals
MenB	Booster dose in adolescence*	Recommended even if vaccinated in infancy due to waning immunity
MenACWY	Booster in adolescence	Maintains protection during high carriage age
HPV	Primary vaccination	Ideally before sexual debut
dTpa	Booster	Reinforcement of waning immunity

* booster dose of the same vaccine received during infancy.

Tab. II. Vaccination coverage among adolescents in Italy for selected vaccines.

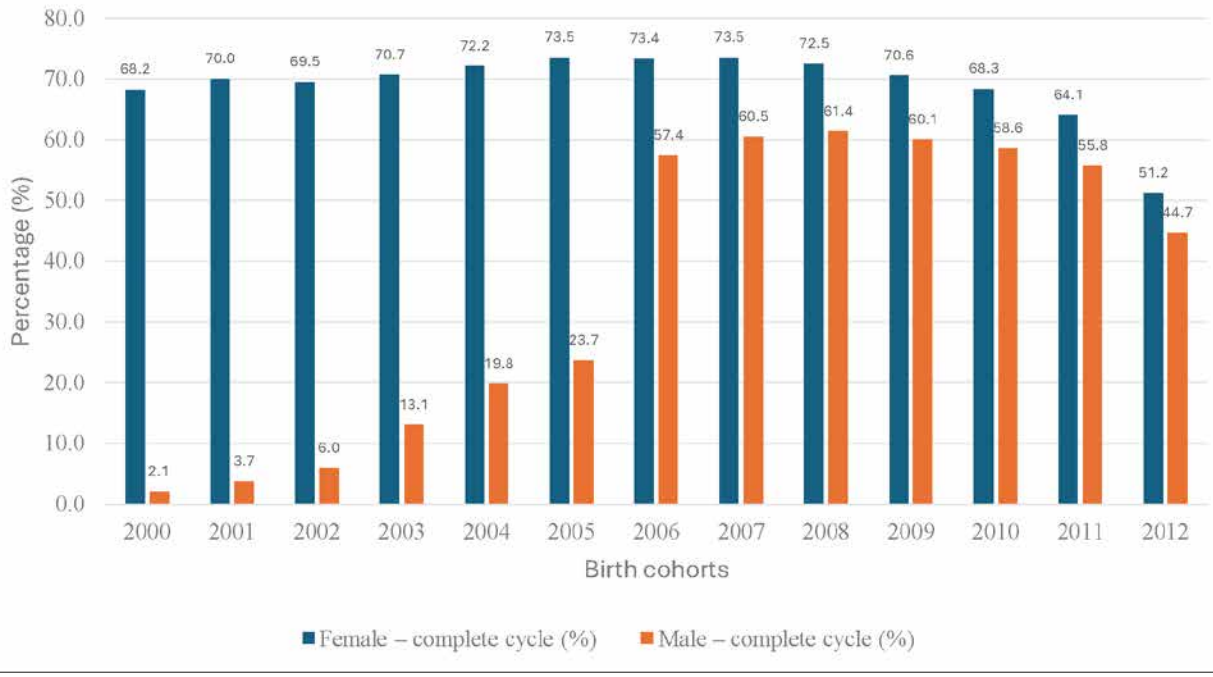
Vaccine	Target age group	National coverage (approx.)	Regional variability	Inclusion in LEA	Key references
HPV (female)	15 years	76.5% (full cycle)	37.8%-82.9%	Yes	[13]
HPV (male)	15–17 years	58.4%	27.9%-78.9%	Yes	[13]
MenB	15-17 years	16.6%*	5.0%–28.3%*	No	[14]
MenACWY	16 years	62.1%	0.2%-89.1%	Yes	[47]
dTpa	16 years	65.4%	25.5%-87.3%	Yes	[47]

* Retrospective administrative database study from a subset of Local Health Units in Veneto, Friuli-Venezia Giulia, Lazio, Liguria and Umbria, representing about 20% of the regional population. Non-naïve adolescents who received a 2-dose schedule during infancy (2009-2011 birth cohorts).

recognition of infections, such as meningococcal disease and HPV, increases the risk of severe health outcomes, including long-term neurological sequelae and cancer [11, 12]. Ensuring high vaccination coverage in this age group not only protects individual health but also strengthens herd immunity, reducing transmission within the broader community [2].

Despite being part of the national vaccination schedule, adolescent vaccination coverage remains low, especially for HPV and MenB vaccines (Tab. II). The completion

Fig. 2. HPV vaccination coverage in Italy by birth cohort and gender. Bars represent the percentage of individuals who completed the full HPV vaccination course, by sex and birth cohort (2000–2012). National data updated to 31 December 2024 (Italian Ministry of Health) [47].



rate for HPV vaccination varies considerably: while some regions achieve coverage rates of up to 80% in females and 75% in males (Lombardy and Umbria), others fall below 60%, far from the national target of 95% (Fig. 2) [13]. MenB vaccination coverage data are lacking the national level. In a retrospective administrative database study from a subset of Local Health Units in 5 Italian regions (Veneto, Friuli-Venezia Giulia, Lazio, Liguria, and Umbria), only 5.0-28.3% of adolescents (2009-2011 birth cohorts) were vaccinated according to a 2 dose-schedule during infancy [14]. Moreover, MenB vaccination coverage is not monitored at national level, leading to the lack of indications for regional target immunization goals to be achieved, which are essential for reaching herd immunity. These disparities are critical, considering that the current National Vaccination Prevention Plan (PNPV 2023-2025) explicitly highlights the need for regional policies to expand adolescent vaccine access [9].

Establishing a dialogue between adolescents and their parents is very complex, because, at this age most adolescents often exhibit a psychological sense of invulnerability and short-term thinking, which reduces their perceived need for preventive health interventions such as vaccination [11, 15]. Moreover, decisions on their health are legally taken by parents who need to be informed in order to promote prevention [11]. Structural and relational barriers further hinder vaccine uptake: these include embarrassment, difficulty accessing services during school hours, and limited trust in adult providers [5]. Autonomy, however, has been identified as a significant enabler; adolescents empowered to make autonomous health decisions show a more positive attitude towards vaccines [6]. Thus, strategies to improve coverage must account for both cognitive-emotional factors and logistical obstacles.

In Italy, adolescents' access to primary care is shaped by a transition in provider roles. Pediatricians follow about 79% of individuals aged 7 to 14 years, focusing on prevention, screening, and scheduled vaccinations [4, 16]. After age 14, most adolescents are seen by general practitioners (GP), often in the context of acute or chronic disease management rather than preventive care [4]. This transition phase is associated with a risk of care discontinuity, especially when preventive measures like vaccinations are not actively addressed by the new provider.

Trusted information sources play a crucial role in shaping adolescents, vaccine decisions. Family, school-based education, sports physicians, and online platforms, especially social media such as TikTok, significantly influence attitudes toward vaccination [2, 7, 8]. Engagement by trusted figures, including teachers, athletes, and healthcare providers, can effectively counteract misinformation [8].

The epidemiological rationale: why HPV and MenB?

Vaccination against MenB and HPV during adolescence is grounded in strong epidemiological evidence highlighting both the clinical burden and public health relevance of these infections. Although MenB disease is relatively rare, its clinical course is often rapid and severe, with a fatality rate between 8-15% even when promptly treated, and up to 60% of survivors experiencing long-term neurological or physical

sequelae [12, 17, 18]. Adolescents and young adults are particularly relevant for transmission, being the age group with the highest carriage rates-up to 5.3 times higher than in other age groups [2, 12]. Moreover, recent data from Italy show that in 2024, among 115 cases of invasive meningococcal disease, serogroup B was the most prevalent across all age groups, accounting for 61 cases and being exclusively detected in children under 10 and persistently found among 15-24-year-olds [19].
In the same period, adolescents aged 15-24 years showed an incidence rate of 0.39 per 100,000, the second highest after infants <1 year (2.36/100,000), reinforcing the need for targeted adolescent immunization strategies [19]. As healthy carriers, adolescents also represent a critical reservoir for community transmission, especially in social settings like schools, dormitories, or nightlife venues, making vaccination not only a personal protection tool but also a public health intervention to reduce overall transmission [3, 12]. Healthy young adults of reproductive age may also represent a significant source of infection for newborns, when asymptomatic carriers [20].
Similarly, HPV infection represents a ubiquitous and often asymptomatic sexually transmitted infection that, while frequently resolving spontaneously, may persist and lead to precancerous lesions and invasive cancers at multiple anatomical sites [21, 22]. Persistent HPV infection is implicated in virtually all cases of cervical cancer and is increasingly recognized in oropharyngeal and anogenital cancers, with an annual global burden of 570,000 cervical cancer cases, including 2,400 in Italy, and a significant proportion caused high-risk HPV genotype 16 and 18 [22-24].
In addition to the oncogenic role, HPV also causes non-malignant conditions such as genital warts, which are common among sexually active adolescents and young adults, especially males [21]. HPV vaccination is unique, alongside HBV, as a cancer-preventing immunization, and its role is central to the WHO's strategy to eliminate cervical cancer by 2030, which includes achieving high vaccination coverage as one of the three pillars [23].
The prevalence of HPV and its asymptomatic nature, combined with the early onset of sexual activity in adolescence, supports the rationale for vaccination at 11-14 years, before potential exposure [11, 25]. The Europe's Beating Cancer Plan and the Italian National Cancer Plan both identify HPV vaccination as a strategic priority, yet current coverage in Italy remains well below the 95% target, with national rates below 70%, and with a high variability in coverage rates for the full cycle observed in the different Italian regions [26, 27].

The institutional framework for adolescent vaccination in Italy: The National Immunization Prevention Plan (PNPV) and the LEA

The National Immunization Prevention Plan (PNPV) represents the primary regulatory and planning instrument guiding immunization policy in Italy [28]. The 2023-2025 edition aims to reduce the burden of vaccine-preventable diseases, including invasive meningococcal disease and HPV-related cancers, through a structured and coordinated national strategy based on scientific evidence and public health priorities [9]. Moreover, the PNPV 2023-2025 explicitly recognizes adolescence as a critical phase for immunization and encourages regions to adopt policies aimed at expanding vaccine access, improving uptake, and reducing inequalities.
The PNPV defines the vaccines included in the Essential Levels of Assistance (LEA), ensuring universal and free access across the country. Within the adolescent age group, HPV vaccination is currently included in the LEA, while MenB vaccination remains excluded. As a result, the implementation of MenB vaccination in this age group is delegated to regional health authorities, leading to heterogeneous access and marked variability in vaccination coverage across Italian regions [2, 12].
In this context, the PNPV serves as the institutional backbone of vaccination policy in Italy, defining mandatory and recommended offers, funding mechanisms, and organizational responsibilities. The PNPV encourages regions to expand their vaccination programs, using the infrastructure and methods developed during the pandemic to improve access and coverage [28], and its effectiveness in the adolescent population depends on regional implementation, the availability of active call–recall systems, and integration with healthcare, educational, and community-based services.

Scientific framework: the Italian "Calendar for Life" and evidence-based recommendations for adolescent vaccination

Alongside the institutional framework defined by the PNPV, adolescent vaccination strategies in Italy are supported by a robust scientific framework represented by the "Calendar for Life" (Calendario per la Vita), a lifetime immunization schedule jointly developed by major Italian public health and scientific societies (Fig. 1). Unlike the PNPV, the Calendar for Life is not a regulatory document but reflects a shared, evidence-based scientific consensus on optimal vaccination strategies across the life course [10].
The Calendar for Life emphasizes that infant-only immunization strategies are insufficient to ensure lifelong protection and strongly supports the role of adolescence as a strategic window for booster and catch-up vaccinations. In this framework, co-administration of vaccines such as MenB, MenACWY, Tdap, and HPV during adolescence is recommended to maximize protection, reduce missed opportunities and improve adherence [10, 26]. A recent the resurgence of measles in Italy, with 529 cases reported by the end of 2025, the administration of a MMR vaccine booster during adolescence represents a valuable strategy to reinforce

immunity and limit onward transmission, particularly to vulnerable populations such as infants [29].
The schedule includes specific indications for both vaccine-naïve adolescents and those previously vaccinated in early childhood (Fig. 1). For meningococcal B vaccination, the Calendar for Life highlights the need for an adolescent booster dose to restore and maintain protective antibody levels in individuals immunized during infancy. Immunological evidence indicates a significant decline in bactericidal antibody titers approximately 7.5 years after completion of the primary series [12]. Furthermore, the activation of the B-cell response requires 5-7 days, underlining the importance of timely booster administration before periods of increased exposure risk [10, 30].
A single booster dose administered during adolescence has been shown to elicit a rapid and robust immune response, with rates ranging from 93% to 100%, consistent with the presence of strong immunological memory [12]. This strategy reduces the number of required doses and healthcare visits, improves cost-effectiveness, and increases the likelihood of completing the vaccination schedule [12, 31].
By defining an ideal, evidence-based immunization pathway, the Calendar for Life complements the institutional framework established by the PNPV. While it does not carry regulatory authority, it provides scientific guidance to support harmonized vaccination strategies, inform regional policies and promote equitable and comprehensive adolescent immunization across Italy [10, 12].

Vaccine policies: what's on the table for adolescents?

The optimal age for adolescent vaccination, particularly between 12 and 14 years, remains a subject of strategic evaluation due to differences in logistical feasibility, immunogenic response, and provider roles. Vaccinating at 12 years aligns with the school calendar and allows paediatricians, who typically follow patients until age 14, to play a proactive role in vaccine counselling and delivery [10]. Co-administration of multiple vaccines, including MenB, MenACWY, DTPa and HPV, is also more feasible in early adolescence, ensuring higher adherence with fewer appointments [31, 32]. Moreover, studies suggest that immunogenicity is robust in this age range, with early administration facilitating timely protection before increased exposure to infection risks [12].
Regarding HPV, the current strategy in Italy falls short of national and European goals. The Europe's Beating Cancer Plan and the Italian Oncologic National Plan aim to eradicate HPV-related cancers, yet coverage remains well below targets [23, 26]. Nationwide, only around 70% of adolescents complete the full HPV vaccination cycle, with a significant drop between the first and second doses [26]. This gap has prompted calls for extraordinary catch-up campaigns and the expansion of vaccination to adult cohorts, at 25 years of age to unvaccinated women during the first cervical screening, and for high-risk groups such as those with HPV lesions or immunocompromised conditions [27].
In this context, extending the adolescent immunization window, integrating vaccine appointments with sports or school activities and leveraging booster doses with co-administration strategies could significantly increase uptake while reducing barriers to access [12, 33]. These policy levers, supported by existing scientific and economic evidence, represent actionable steps toward closing the adolescent vaccination gap in Italy.

The Italian landscape: regional offer and disparities

The current national framework for adolescent vaccination in Italy reflects substantial regional heterogeneity in both policy implementation and coverage outcomes, with the absence of MenB in the national PNPV as a major cause for these regional disparities [23].
Regarding MenB vaccine, 14 regions have introduced active vaccination offers for adolescents. However, only six of these regions extend the offer to non-naïve individuals (with booster dose of the same vaccine received during infancy), thus limiting access for many adolescents at continued clinical risk (Tab. III) [9, 10, 27]. Veneto and Emilia-Romagna stand out for having introduced structured regional programs that actively offer MenB vaccination to adolescents, including clear guidelines on co-administration with other recommended vaccines such as ACWY, dTpa, and HPV. Although precise coverage rates are not always publicly available, both regions are often referenced in national reports as examples of proactive implementation, supported by early communication campaigns and integration with adolescent health services [10, 34, 35]. The higher coverage estimates from some regions reflect proactive local health strategies, including targeted communication and integration of vaccination within broader adolescent health services [12]. Liguria and Lombardia have also provided detailed guidelines for managing non-naïve adolescents, integrating MenB into their adolescent vaccination calendars along with ACWY and HPV vaccines [9, 36, 37].
Similar disparities exist in HPV vaccination coverage, despite being part of the PNPV since 2007. However, some regions serve as models of excellence exemplifying effective integration of vaccination with broader public health strategies. Notable examples of high-performing regions include Lombardia, which is among the Italian regions achieving relatively high adolescent vaccination coverage with first-dose HPV vaccination coverage among 15-year-old girls reaching around 80% [13]. This region has pioneered pharmacy-based vaccination delivery, improving convenience and coverage among adolescents and young adults and, therefore, contributing substantially to overall immunization campaigns (*e.g.,* including influenza, COVID-19, pneumococcus, RSV) [28].
In Trento, health authorities implemented a proactive,

Tab. III. Policy and implementation strategies of adolescent vaccination programs in selected Italian regions.

Region	MenB Offered to Adolescents*	HPV Offered to Adolescents*	Type of immunization registry (*diversity in the software systems and data flows in place.*)	Notable
Veneto	13 years of age (2-dose cycle or booster dose for not naïve and naïve subjects, respectively) co-administered with other age-targeted vaccines.	Girls and boys of 13 years of age. Passive offer on request and active offer to 25-year-old women on their first cervical screening appointment.	Full computerised, same software, individual data real-time.	Active recall [27].
Lombardia	11-18 years of age (2-dose cycle or booster dose for not naïve and naïve subjects, respectively) co-administered with other age-targeted vaccines. Active call at 12 years of age.	Girls and boys up to the age of 26 (2 or 3 dose-schedule depending on age).	Full computerised, different software, individual data real-time.	University Open Days Pharmacy-based HPV campaigns [27].
Trento	14 years of age (active call from 2009 birth cohort). Catch-up for men up to age 30 and women up to age 40 who have not been vaccinated previously.	Girls and boys at 11-14 years of age (catch-up call for naïve young men up to age 30 and naïve young women up to age 40).	Full computerised, different software, individual data real-time.	Screening + gynecology referral for HPV [36].
Tuscany	Active offer to 12 years of age (from 2013 birth cohort) co-administered with other age-targeted vaccines (2-dose cycle or booster dose for not naïve and naïve subjects, respectively)	Girls and boys 10 years of age.	Full computerised, same software, individual data real-time.	Integrated paediatricians into the vaccination system [27]. Network model (meetings with GPs and paediatricians, local media communication, increased opening hours of vaccination clinics and continuous monitoring of vaccination status) [52, 53].
Emilia-Romagna	Active offer to 13 years of age (starting with 2011 birth cohort) as 2-dose cycle or booster dose for not naïve and naïve subjects, respectively) co-administered with other age-targeted vaccines. Offered to 17 years of age (2007 birth cohort) if parents requested and regardless of vaccination status.	Girls and boys at 11-15 years of age (2 or 3 dose-schedule depending on age). Catch-up vaccination for women up to the age of 26, provided by the first cervical cancer screening, and for men at least up to the age of 18 if naïve or have not completed the vaccination cycle.	Full computerised, different software, individual data quarterly.	Active call policies (Regional Act 1045/2019) [54].
Marche	Actively offered free of charge to the cohort of 11-year-olds (born in 2013 or later) in co-administration with the HPV papilloma virus vaccine. A booster is also recommended for not naïve adolescents who received vaccination at 2 years of age (same vaccine used for the primary series).	Girls and boys at 11-18 years of age (2 doses for 11-14 year group and 3 doses for 15-18 years).	Full computerised, same software, aggregate data annually.	Active call policies [31].
Lazio	Years of age.	Girls and boys 11-25 years of age (from 2006 birth cohort)	Full computerised, different software, aggregate data annually.	Active recall systems for MenB and HPV.
Campania	12 years of age, co-administration with tetravalent MenACYW vaccination.	11-48 years of age.	Partially computerised, different software, aggregate data annually.	New digital system, but passive campaigns [39].

Tab. III (*follows*). Policy and implementation strategies of adolescent vaccination programs in selected Italian regions.

Region	MenB Offered to Adolescents*	HPV Offered to Adolescents*	Type of immunization registry (*diversity in the software systems and data flows in place*)	Notable
Sicily	11-18 years of age for naïve subjects (2 dose schedule) and 15-18 years for subjects previously vaccinated with 2 or 3 doses during childhood (2 dose schedule)	11-14 years of age (2 dose-schedule) and, from 15 years of age (3 dose-schedule) free of charge for cohorts born from 1996 onwards for females and from 2003 onwards for males, where not yet vaccinated. Offered as a co-payment for female birth cohorts <1996 and male birth cohorts <2003	Full computerised, different software, individual data real-quarterly	Low uptake, socio-economic barriers [39]
Puglia [55]	11-12 years of age, co-administration with tetravalent MenACYW vaccination	Girls and boys of 11-17 years of age (2-dose schedule for 11-14 years old, 3-dose schedule for subjects 14-18 years)	Full computerised, same software, individual data real-time	NA
Basilicata [56]	From 11 years of age	Girls and boys of 11-17 years of age (2-dose schedule for 11-14 years old, 3-dose schedule for subjects 14-18 years). Offered to 24-year-old women not previously vaccinated, on their first cervical screening appointment	Full computerised, same software, individual data real-time	NA
Calabria [57]	11-17 years of age (2 dose schedule)	Girls and boys of 11-17 years of age (2 or 3 dose schedule depending of age). Offered to 25-year-old women not previously vaccinated	Partially computerised, same software, aggregate data annually	
Liguria	11-17 years of age. Active call for 13-14-years-old subjects not previously vaccinated, co-administered with MenACWY. A booster is also recommended for not naïve adolescents who received vaccination at 2-10 years of age (same vaccine used for the primary series)	Girls and boys 11-19 years of age (2-dose schedule). Offered to women until the start of cervical screening (dose schedule according to SmPC vaccines in use)	Full computerised, different software, individual data annually	Pharmacy-based HPV campaigns [27].
Molise [58]	Active offer to 13 years of age (starting with 2011 birth cohort). Offered to 17 years of age (2007 birth cohort) if parents requested and regardless of vaccination status	Girls and boys of 11-17 years of age (2-dose schedule for 11-14 years old, 3-dose schedule for subjects after 15 years). Catch-up call for subjects up to 25 years	Full computerised, same software, aggregate data annually	NA

* Indicated as full years of age. NA: not available.
This table summarizes MenB vaccine inclusion, HPV offer, registry infrastructure, delivery models, and strategic innovations across key regions. Vaccine indications for special populations are not included [2, 10, 24, 28, 33-41, 44, 48-60].

structured campaign combining screening, outreach, and broad agecohort targeting, extending immunization beyond traditional pediatric ages. A successful HPV extension model to adult cohorts through integration with screening programs and seamless referral from gynecological services achieved 86% adherence [38].

Piemonte is another region that adopted early and proactive strategies, including extension of vaccination offers to broader age cohorts, offering the vaccine to all individuals aged 11 and above, and providing facilitated pathways for high-risk populations such as HIV-positive men and women with cervical lesions [39].

By contrast, in southern regions such as Sicily, completion rates remained below 50%, underscoring the need for enhanced outreach, especially among socioeconomically disadvantaged groups [13].

Another key structural issue limiting equity and efficiency is the inconsistent accessibility of vaccination registries across regions (Tab. III). Vaccination registries integrated with a unified vaccination software system allow for real-time monitoring of coverage rates across local health districts (SSTs), identification of underperforming areas, and implementation of targeted recovery strategies. Some regions, such as Lombardia,

with its ARVAX software, enable healthcare providers to verify vaccination status in real time and even extract data from entire cohorts, facilitating targeted interventions and outreach [27]. In contrast, in other regions, pediatricians and general practitioners may either lack access entirely or face bureaucratic hurdles, reducing the ability to track missed vaccinations and plan catch-up campaigns [27].

"Symphony of Health" platform, adopted by Campania Region, is a computerised vaccination registry designed to improve vaccination coverage, prevent epidemics and facilitate collaboration between paediatricians and general practitioners. The system allows healthcare professionals to consult the vaccination status of every citizen in real time, monitor susceptible cohorts and launch booster campaigns for unprotected individuals, exchange of information between paediatricians and general practitioners to promote continuity of care during the transition from childhood to adulthood [40].

Nonetheless, active call systems, which are crucial for achieving high vaccination uptake, are still not uniformly implemented nationwide. Regions like Lazio have established systematic recall systems for HPV and MenB, often in collaboration with primary care physicians, but other regions such as Sicily and parts of Campania still rely on passive models, contributing to persistently low coverage [41]. This patchwork of policies and practices not only undermines national vaccination goals but also exacerbates health inequalities among adolescents across different parts of Italy.

These disparities underscore the need for national alignment, starting through the inclusion of MenB in adolescent PNPV to active monitoring strategies, supported by ISS data and scientific society recommendations. Establishing clear coverage goals and equitable access mechanisms will be essential to ensuring uniform adolescent protection across the country.

Overcoming vaccine fatigue: adolescent engagement and communication

In recent years, the phenomenon of "vaccine fatigue" has gained relevance as a barrier to immunization uptake, particularly in adolescence. This form of hesitancy reflects emotional and cognitive overload toward vaccination messages, reduced risk perception, and increasing disengagement from preventive health behaviours [6].

To address this, the European Centre for Disease Prevention and Control (ECDC) proposed the 5C model, which identifies five psychological drivers of vaccination behaviour: Confidence, Complacency, Constraints, Calculation and Collective responsibility [8]. Applying this framework can help public health professionals tailor strategies that improve vaccine acceptance by addressing adolescents' specific cognitive and emotional dynamics.

An US study assessed how physicians communicate with patients/parents regarding meningococcal vaccinations, aiming to identify barriers to the implementation of a shared clinical decision making (SCDM) between patients/parents and providers. SCDM recommendation of MenB vaccination for adolescents and young adults resulted inconsistently understood and implemented, because implementing SCDM required to physicians more time and discussion with patients, which could pose a barrier to discussing vaccination [42].

The digital environment plays a dual role in shaping attitudes: while it offers opportunities for health communication, it also poses risks due to the spread of misinformation. Social media platforms like TikTok and Instagram are increasingly used by adolescents as sources of health information; although, these platforms often contain misleading or ambiguous content regarding vaccine safety and efficacy [7]. Real-time social media monitoring initiatives, such as the EU-JAV platform coordinated by the National Institute of Health proved the feasibility of tracking online discourse to inform targeted communication campaigns [43]. However, tackling disinformation also requires stronger roles for trusted figures, such as family, healthcare providers, and schools, in guiding adolescents toward informed health choices [2, 25].

Schools represent a key setting for both education and vaccine delivery. Structured campaigns in regions like Puglia (Taranto) have combined in-school education, parental engagement, and open vaccination access, achieving notable improvements in HPV vaccine coverage [28]. Peer-to-peer education in university settings has also proven effective and may be scalable to secondary schools. In Lombardy, on November 2024, HPV vaccine free of charge together with detailed information on cervical cancer prevention programs and vaccination centres were offered to males and females up to 26 during Open Days at local universities, in collaboration with regional Health Protection Agencies (ATS) [44].

Nevertheless, these experiences remain fragmented and call for a nationally coordinated school-based vaccination strategy integrated into health education curricula [2].

In line with a comprehensive and inclusive communication strategy, community initiatives like the "*Carta di Loreto"* and the "*Manifesto for HPV Cancer Elimination"* have emerged to raise awareness and foster collective commitment toward vaccination. These documents bring together institutions, healthcare professionals, and civil society to promote accessible and evidence-based immunization campaigns, especially for HPV [33, 45].

A multi-actor approach is essential. Pediatricians and general practitioners remain pivotal as vaccine counsellors. Adolescents aged 7-14 are primarily followed by family paediatricians, with the transition to general practitioners often occurring after age 14 (SIP39). During this phase, adolescents risk falling into a healthcare gap that may delay vaccinations [4]. Encouraging paediatricians and GPs to proactively verify immunization status, counsel families and report

updates into regional registries can close this gap [12].
Sports medicine professionals are another strategic but poorly engaged resources. Given their regular interaction with healthy adolescents during mandatory medical evaluations for competitive sports, these professionals can verify vaccine status and promote preventive measures, particularly against infections like HPV and meningococcal disease, which have high transmission potential in communal environments [2, 6, 12]. A notable example comes from the collaboration between the Italian Sports Medicine Federation (FMSI) and regional health services, where sports physicians actively engage in health education during medical evaluations. This includes raising awareness about the risks of vaccine-preventable diseases like meningitis and HPV, particularly given the increased risk of transmission in communal environments such as locker rooms and training facilities. Athletes, due to their visibility and public influence, can also serve as powerful advocates for preventive health behaviors and play a vital role in promoting public awareness about vaccination campaigns, particularly among younger and more hesitant populations [46].
Ultimately, fostering adolescent engagement in vaccination requires synergistic efforts from schools, healthcare professionals, families and community institutions. Tailored, age-appropriate communication strategies grounded in behavioural science, such as the 5Cs, should be deployed alongside flexible, accessible vaccine delivery models to overcome vaccine fatigue and enhance coverage.

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Conflicts of interest statement

All authors declare that they have no conflicts of interest.

Author's contributions

All authors contributed equally to this work.

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