Journal of Infection and Public Health 18 (2025) 102875

Contents lists available at ScienceDirect

Journal of Infection and Public Health

journal homepage: www.elsevier.com/locate/jiph

Original article

Influenza vaccination coverages in Italy from 1999/00 to 2023/24: A joinpoint regression analysis

Andrea Zaino [a,b,1], Michele Bonacquisti [a,b,1], Luigi Russo [a,*], Tiziana Sabetta [a,b], Alessandro Solipaca [a,b], Walter Ricciardi [a,b], Stefania Boccia [a,c], Leonardo Villani [a,b,d]

[a] Section of Hygiene, University Department of Life Sciences and Public Health, Università Cattolica del Sacro Cuore, Rome, Italy
[b] Osservatorio Nazionale sulla Salute nelle Regioni Italiane – Osservasalute, Università Cattolica del Sacro Cuore, Rome, Italy
[c] Department of Woman and Child Health and Public Health, Fondazione Policlinico Universitario A. Gemelli IRCCS, Rome, Italy
[d] UniCamillus - Saint Camillus International University of Health and Medical Sciences, Rome, Italy

ARTICLE INFO

Article history:
Received 30 December 2024
Received in revised form 8 April 2025
Accepted 16 June 2025

Keywords:
Vaccination
Influenza
Flu
Public Health
Trend analysis
Joinpoint regression

ABSTRACT

Background: Influenza is a contagious respiratory viral infection with significant health and economic impacts, causing millions of cases and hundreds of thousands of deaths annually worldwide. In Italy, annual epidemics affect approximately 8 % of the population. Vaccination remains the most effective prevention strategy, yet coverage in Italy is low and consistently below the WHO-recommended threshold of 75 % in elderly. This study aims to analyze trends in influenza vaccination coverage in Italy from 1999/2000 to 2023/2024 through joinpoint regression analysis.

Methods: Data on influenza vaccination coverage were obtained from the Italian Ministry of Health, covering the general population and specific age groups. The analysis included data from the 1999/2000 season to the 2023/2024 season. Joinpoint regression was used to identify significant changes in coverage trends over time, calculating Annual Percentage Change (APC) and Average Annual Percent Change (AAPC).

Results: Coverages vary between and within age groups over the study period. The pediatric population showed the lowest values, never exceeding 10 % except for the COVID-19 pandemic years. Similar trends, albeit with higher coverage, were observed in the adult population. In the elderly population, the WHO target of 75 % was never reached, obtaining the highest value of 68.3 % in 2005/2006. Trends show increasing AAPC coverages for all groups except 15–17 years. During the pandemic, increases in coverages are observed in all age groups, but these decline towards pre-pandemic values during the following seasons.

Conclusions: Our study shows that vaccination coverage in Italy falls below target thresholds, particularly in high-risk age groups, with a significant decreasing trend observed in the years following the pandemic across almost all age groups. Despite the proven efficacy and safety of the vaccine, hesitancy has gained momentum in Italy, resulting in persistently low coverage rates. Our findings highlight the need for a multifaceted approach, including expanding free vaccination programs, implementing school-based initiatives, strengthening healthcare worker engagement, and enhancing public awareness campaigns. A coordinated national effort, led by the Ministry of Health, is essential to achieving higher coverage rates and reducing the burden of influenza.

Introduction

Influenza is a ubiquitous, acute, highly contagious respiratory viral infection with seasonal, epidemic, and pandemic patterns, with a significant health and economic impact [1–3]. Indeed, the World Health Organization (WHO) reported about 1 billion cases of influenza worldwide each year, with 3–5 million severe cases and 290,000–650,000 deaths [4]. Similarly, the European Center for Disease Control (ECDC) estimates 4–50 million symptomatic cases of influenza occurring annually in Europe and from 15,000 to 70,000 deaths due to influenza-related causes, mainly in people with underlying chronic conditions [5]. In Italy, as in the rest of Europe, influenza occurs with annual epidemics during the winter season, affecting, albeit with fluctuations, about 8 % of the population each year [6]. In this context, influenza represents a major public health

* Correspondence to: Section of Hygiene, University Department of Life Sciences and Public Health, Università Cattolica del Sacro Cuore, Rome 00168, Italy.
E-mail address: luigi.russo12@icatt.it (L. Russo).
[1] Andrea Zaino and Michele Bonacquisti equally contributed to the work.

https://doi.org/10.1016/j.jiph.2025.102875
1876-0341/

issue in terms of health and social costs, with an economic impact mainly associated with increased hospitalizations, healthcare needs, pharmaceutical expenditure, school and work absenteeism and loss of productivity [7].

Vaccination is the most effective and safest tool to prevent influenza and reduce its complications [8]. Thus, vaccination coverage is the key indicator, as it provides information on the implementation and the efficiency of the vaccination strategies and the adherence of the population. Despite the proven efficacy of influenza vaccines, coverages in Italy, as well as in many European Countries [9], remains below the threshold recommended by the WHO and the Italian National Vaccination Plan, both aiming at increasing influenza vaccination coverage of high-risk groups and to attain coverage of 75 % among elderly [10]. Similar trends are observed in other European countries, as reported by the annual ECDC influenza vaccination survey, with low coverages reported for elderly, with a reported median VCR for 2023–24 season of 45.7 %, with only Denmark and Ireland reaching the > 75 % target [11].

Achieving and maintaining high vaccination coverage is therefore a public health priority to reduce the health and economic burden of influenza. Vaccination is free of charge in Italy for target categories, including patients with chronic diseases, people over 65 years of age and health workers, and efforts have been made in terms of organizing vaccination campaign and publicizing the vaccination [12,13]. In this context, monitoring coverage trends is a useful tool for analyzing the phenomenon providing accurate data to inform policymakers and implement strategies to increase coverage [14–16]. The aim of this study is to describe the trends in influenza vaccination coverage in the Italian population from the season 1999/2000 to the season 2023/2024 through the joinpoint regression model.

Methods

Data collection

Data on influenza vaccination coverage were extracted from the Italian Ministry of Health website as of October 2024 [17]. We considered the period from the first season available – 1999/2000 (or more recent if data was unavailable) to 2023/2024 (last data available). In our analysis we included coverage presented as the percentage of the general population and the percentage of specific age groups vaccinated against influenza. We included all the groups available: < 2 years, 2–4 years, 5–8 years, 9–14 years, 15–17 years, 18–44 years, 45–64 years and ≥65 years. Data availability varies by age groups: indeed, for the general population and elderly data were available since the season 1999/2000, while the data stratified for the other age groups were available from the season 2010/2011.

Data analysis

We tested the normality of residuals using the Shapiro-Wilk test. A Joinpoint regression was performed to describe changes in influenza vaccination coverage trends. Joinpoint is a regression model used to analyze temporal trend changes across many scientific fields, including vaccination [15,16,18–20]. This model identifies a point ("joinpoint") where parameter shifts occur within a time series. We performed the analysis for each coverage indicator. We considered the year as the independent variable, while the vaccination coverage indicator, expressed as a percentage, as the dependent variable. Homoscedasticity was tested using the Breusch-Pagan test, which revealed heteroscedasticity only in the 65+ age group. To account for this, standard errors were calculated and incorporated using the "provided standard errors" option in the Joinpoint software. All the other age group presented constant variance (homoscedasticity) for coverage rates. Furthermore, the joinpoint model calculates the Annual Percentage Change (APC), indicating increases or decreases in vaccination coverage over time for each interval considered, and the Average Annual Percent Change (AAPC), a measure of the trend over the whole interval considered, computed as a weighted average of the APCs from the joinpoint model. A logarithmic transformation was applied to the annual vaccination percentages using the model ln(rate) = b × years, where years represents calendar years, b is the regression coefficient, and rate indicates vaccination prevalence. This transformation allows for the interpretation of Annual Percent Changes (APCs) and Average Annual Percent Changes (AAPCs) in terms of percentage variation.

The software predicts a minimum of 0 to a maximum of 5 joinpoints, showing the presence of changes in the trend, considered significant when $p < 0.05$.

Furthermore, autocorrelation was examined with the Ljung-Box test; first-order autocorrelation was identified in the residuals of both the general population and the 65+ age group. Accordingly, the "first-order autocorrelated errors" option was applied in Joinpoint to address this issue.

For the analysis we used the Joinpoint Trend Analysis Software 5.0.2 – Desktop Version, available from the Surveillance Research Program of the US National Cancer Institute [21].

Results

General population

The trend of vaccination coverage in the general population shows variations over the period considered, with a minimum observed in 1999/2000 (10.5 %) and a maximum in 2020/2021 (23.7 %) (Table 1). Joinpoint analysis identified three changes in the trend, resulting in five intervals (Fig. 1 and Table 2). The first interval considered the seasons from 1999/2000 to 2003/2004, with a significant increase in coverage, up to 17.5 % (APC = +13.33 %, 95 %CI: 9.06–23.27, p = 0.0008). From 2003/04 to 2009/10, the trend plateaued, with a non-significant increase in the APC of 1.34 % (95 % CI: −1.93–5.33, p = 0.3). From 2009/2010 to 2015/2016 we observed a significant reversal in the trend (APC = −6.08 %; 95 %CI: −11.30 to −3.82, p = 0.0076), with a reduction of coverage from 19.6 % in 2009/2010 to 13.9 % in 2015/2016. Coverage increased significantly from 2015/2016 to 2021/2022, with an observed APC of +8.49 % (95 %CI:6.25–14.67, p = 0.0084). We observed a peak (23.7 %) in 2020/2021 season, corresponding to the onset of the COVID-19 pandemic. Finally, in the last trend between the 2021/2022 and 2023/2024 season coverage declined again (non-significant) with an APC of −6.75 %. (95 %CI: −13.07–2.26, p = 0.14). During such period, coverage decreased to a minimum reached in the 2023/2024 season with a value of 18.9 %.

Overall, from 1999/2000 to 2023/2024, there was an increase of coverage (AAPC = +2.33 %, 95 %CI: 1.75–3.00 %, p = 0.000000) (Table 3). This value indicates a positive trend despite the intermediate fluctuations in coverage, even though it never reached values > 25 %.

Coverage by age groups

Pediatric population < 2 years

Coverage ranged from a low of 1.1 % (2014/2015 and 2015/2016) to a high of 9.8 % (2023/2024) over the considered period (Table 1). The analysis showed 1 joinpoint in the 2015/2016 season (Fig. 2A and Table 2). Thus, from 2010/2011 to 2015/2016, we observed a significant decline in coverage (APC = −18.70 %; 95 %CI: −44.47 to −2.29, p = 0.02), followed by a significant increase from 2015/2016 to 2023/2024 (APC= +36.99 %; 95 %CI: 24.94–61.04 p < 0.0001). Overall, we observed an AAPC of +12.08 % (95 %CI: 5.84–18.66, < 0.000001) (Table 3). The most significant increase (from 2.8 % to 9.2 %, +228.6 %) is observed from 2019/2020 to the beginning of the COVID-19

Table 1
Influenza vaccination coverages in Italy from 1999/2000 to 2023/2024 by age group.

Season	< 2 years	2–4 years	5–8 years	9–14 years	15–17 years	18–44 years	45–64 years	≥65 years	Overall
1999/2000	-	-	-	-	-	-	-	40.7	10.5
2000/2001	-	-	-	-	-	-	-	50.7	12.6
2001/2002	-	-	-	-	-	-	-	55.2	14.1
2002/2003	-	-	-	-	-	-	-	60.3	15.6
2003/2004	-	-	-	-	-	-	-	63.4	17.5
2004/2005	-	-	-	-	-	-	-	66.6	17.7
2005/2006	-	-	-	-	-	-	-	68.3	19.4
2006/2007	-	-	-	-	-	-	-	66.6	18.6
2007/2008	-	-	-	-	-	-	-	64.9	18.4
2008/2009	-	-	-	-	-	-	-	66.3	19.1
2009/2010	-	-	-	-	-	-	-	65.6	19.6
2010/2011	2.9	4.5	4.3	3.8	3.5	3.6	12.2	62.4	17.9
2011/2012	2.2	4.2	4.5	3.3	3.6	3.4	12	62.7	17.8
2012/2013	1.5	2.6	2.6	2	2.1	2.1	9	54.2	14.9
2013/2014	1.3	2.5	2.6	2.1	2.3	2.5	9.5	55.4	15.6
2014/2015	1.1	1.8	1.9	1.5	1.5	1.9	7.5	48.6	13.6
2015/2016	1.1	1.8	1.8	1.4	1.6	1.8	7.7	49.9	13.9
2016/2017	1.5	2.6	2.4	1.8	1.9	2.2	8.5	52	15.1
2017/2018	1.4	2.4	2.2	1.8	2.5	2.2	8.7	52.7	15.3
2018/2019	1.7	3.1	2.5	1.8	2.2	2.6	8.9	53.1	15.8
2019/2020	2.8	4.2	3.1	1.9	1.9	3.1	9.6	54.6	16.8
2020/2021	9.2	19	13.1	6	4.5	5.9	16.8	65.3	23.7
2021/2022	7	17.4	12.2	4.4	2.5	4.2	13.7	58.1	20.5
2022/2023	7.2	9.2	22.6	4.9	2.1	4.1	13.3	56.7	20.2
2023/2024	9.8	16.7	11.7	4.6	1.9	3.7	11.8	53.3	18.9

pandemic (2020/2021). Coverages declined after this peak, albeit maintaining higher values than previous seasons. In 2023/2024 is observed a new peak, reaching the highest coverage in this age group.

Pediatric population 2–4 years

During the observed period, coverage ranged from 1.8 % (2014/2015 and 2015/2016) to 19.0 % (2020/2021) (Table 1). The analysis identified 1 Joinpoint, dividing the trend into 2 intervals (Fig. 2B and Table 2). In particular, from 2010/2011 to 2015/2016, vaccination coverage showed a downward trend (APC = −18.48 %; 95 %CI: −54.72–2.65, p = 0.09), followed by a significative increase (APC = +36.99 %, 95 %CI: 22.59–87.03, p = 0.0012) until 2023/2024. An increasing AAPC of +12.20 % (95 %CI: 3.98–21.52, p = 0.002) was registered during the entire period (Table 3). Also, in this case an important increase (+352.38 %) was registered during the season 2020/2021, compared with the previous years (from 4.2 % to 19.0 %). However, coverage declined after the peak, albeit maintaining higher values than previous seasons. In 2023/2024 is observed a new peak (16.7 %).

Pediatric population 5–8 years. During the observed period, coverage ranged from 1.8 % (2015/2016) to 22.6 % (2022/2023) (Table 1). One joinpoint was reported (Fig. 2C and Table 2). From 2010/2011 to 2016/2017, vaccination coverage non significantly decreased (APC = −14.50 %, 95 %CI: −54.84–4.80, p = 0.13). Then, a significant increase is observed, with an APC of 43.58 % (95 %CI: 22.21–144.44, p < 0.002). The AAPC showed a significant increase (+13.02 %, 95 %CI: 4.00–23.33, p < 0.003) (Table 3). The overall trend shows a variable pattern with an important increase during the season 2020/2021, a spike in 2022/2023 season but generally decreasing in the next three years.

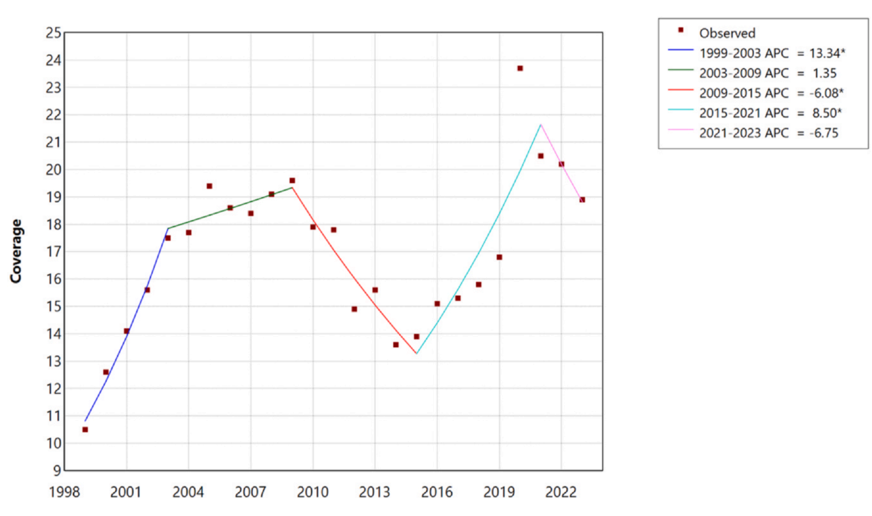

Fig. 1. Trend of vaccination coverage in the general population from 1999/2000 to 2023/2024. The year in the figure corresponds to the season of the same year and the following year. For example, the year 1999 corresponds to the season 1999/2000. *=statistical significance at p < 0.05.

Table 2
Annual percentage change (APC) by age group.

Age group	Lower year	Upper year	APC	LCI	UCI		p value
< 2 years	2010/2011	2015/2016	−18.7030*	−44.4786	−2.2960	–	**0.027994**
	2015/2016	2023/2024	36.9969*	24.9450	61.0438	–	**< 0.000001**
2–4 years	2010/2011	2015/2016	−18.4807	−54.7265	2.6547	–	0.092781
	2015/2016	2023/2024	36.9971*	22.5984	87.0302	–	**0.001200**
5–8 years	2010/2011	2016/2017	−14.5076	−54.8460	4.8085	–	0.134773
	2016/2017	2023/2024	43.5853*	22.2161	144.4444	–	**0.002000**
9–14 years	2010/2011	2015/2016	−18.7276*	−34.3413	−7.7351	–	**0.002000**
	2015/2016	2023/2024	20.2634*	12.8742	32.6520	–	**< 0.000001**
15–17 years	2010/2011	2014/2015	−20.7916*	−39.6029	−8.7725	–	**< 0.000001**
	2014/2015	2020/2021	12.6943*	5.2039	39.5647	–	**0.004799**
	2020/2021	2023/2024	−16.2543*	−37.4446	−1.4295	–	**0.023995**
18–44 years	2010/2011	2015/2016	−14.5056*	−35.9253	−4.0123	–	**0.021196**
	2015/2016	2020/2021	22.6873*	8.4610	52.7461	–	**0.023995**
	2020/2021	2023/2024	−6.2543	−34.0649	10.2605	–	0.372725
45–64 years	2010/2011	2014/2015	−12.4021*	−31.2125	−1.4429	–	**0.018396**
	2014/2015	2023/2024	7.4306*	3.6277	19.2631	–	**0.001200**
> 65	1999/2000	2003/2004	10.7565*	7.5367	18.4444	–	**0.000000**
	2003/2004	2009/2010	0.0219	−1.5388	1.9664	–	0.957009
	2009/2010	2015/2016	−5.1659*	−9.5392	−3.7753	–	**0.002400**
	2015/2016	2020/2021	4.9132*	2.9664	10.0903	–	**0.002799**
	2020/2021	2023/2024	−4.2977*	−10.5785	−1.2464	–	**0.004799**
General population	1999/2000	2003/2004	13.3353*	9.0626	23.2763	–	**0.000800**
	2003/2004	2009/2010	1.3451	−1.9372	5.3308	–	0.329534
	2009/2010	2015/2016	−6.0824*	−11.3052	−3.8230		**0.007598**
	2015/2016	2021/2022	8.4987*	6.2510	14.6755		**0.008398**
	2021/2022	2023/2024	−6.7511	−13.0799	2.2660		0.140772

APC = Annual Percentage Change
LCI = lower confidence interval
UCI = upper confidence interval
* =statistical significance at $p < 0.05$.

Pediatric population 9–14 years

Coverage never exceeded 10 % throughout the period under consideration (maximum value of 6 % in 2020/2021) (Table 1). Joinpoint analysis identified two intervals (Fig. 2D and Table 2): we observed a significant decrease from 2010/2011 to 2015/2016 (APC = −18.72 %, 95 %CI: −34.34 to −7.73, p = 0.002), followed by a significant increase until 2023/2024 (APC = +20.26 %, 95 %CI: 12.87–32.65, p < 0.0001). Overall, an AAPC of +3.43 % (95 %CI: −0.78–7.82, p = 0.104) is observed (Table 3). Also in this age group, coverage reached a higher value in the year of the COVID-19 pandemic outbreak, with lower but stable values in the following three seasons, though higher than the previous period.

Pediatric population 15–17 years

The coverage of this age group is the lowest among all those analyzed, with values never exceeding 5 % during the period considered (highest value of 4.5 % in 2020/2021) (Table 1). Three different intervals are identified by the joinpoint analysis (Fig. 2E and Table 2): from 2010/2011 to 2014/2015 we observed a significant decreasing trend (APC = −20.79, 95 %CI: −39.60 to −8.77, p < 0.00001). In the second interval, from 2014/2015 to 2020/2021 an increasing trend was reported with a significative APC of +12.69 % (95 %CI: 5.20–39.56, p = 0.004). In the last interval, from 2020/2021 to 2023/2024, a significant decrease was found, with an APC of −16.25 % (95 %CI: −37.44 to −1.42, p = 0.02).

The AAPC, unlike the previous ones, presents a negative trend of −5.58 % (95 %CI: −9.35–2.07, p = 0.002) (Table 3). Like the other age groups, also in this case the peak was reached during the onset of the COVID-19 pandemic, with a reduction of coverage in the following seasons.

Adult population 18–44 years

The highest coverage was recorded in 2020/2021 (5.9 %), with an increase (+90.3 %) compared to the season 2019/2020 (3.1 %). Conversely, the lowest value was reported in 2015/2016 (1.8 %) (Table 1). From 2010/2011 to 2015/2016, vaccination coverage showed a significant decrease (APC = −14.50 %, 95 %CI: −35.92 to −4.01, p = 0.02).

Then, from 2015/2016 to 2020/2021, an upward trend is observed (APC = +22.68, 95 %CI: 8.46–52.74, p = 0.02) (Fig. 3A and Table 2).

Table 3
Average annual percentage change by age group.

Age group	Lower season	Upper season	AAPC	LCI	UCI	p value
< 2 years	2010/2011	2023/2024	12.0838*	5.8441	18.6663	**< 0.000001**
2–4 years	2010/2011	2023/2024	12.2017*	3.9813	21.5229	**0.002400**
5–8 years	2010/2011	2023/2024	13.0263*	4.0015	23.3338	**0.003999**
9–14 years	2010/2011	2023/2024	3.4369	−0.7829	7.8240	0.104779
15–17 years	2010/2011	2023/2024	−5.5875*	−9.3594	−2.0769	**0.002000**
18–44 years	2010/2011	2023/2024	0.3467	−4.1161	3.8136	0.891822
45–64 years	2010/2011	2023/2024	0.8918	−2.0713	4.2045	0.469906
> 65	1999/2000	2023/2024	0.8358*	0.3554	1.4401	**0.003199**
General population	1999/2000	2023/2024	2.3351*	1.7559	3.0064	**0.000000**

AAPC = Average Annual Percentage Change
LCI = lower confidence interval
UCI = upper confidence interval
* =statistical significance at $p < 0.05$.

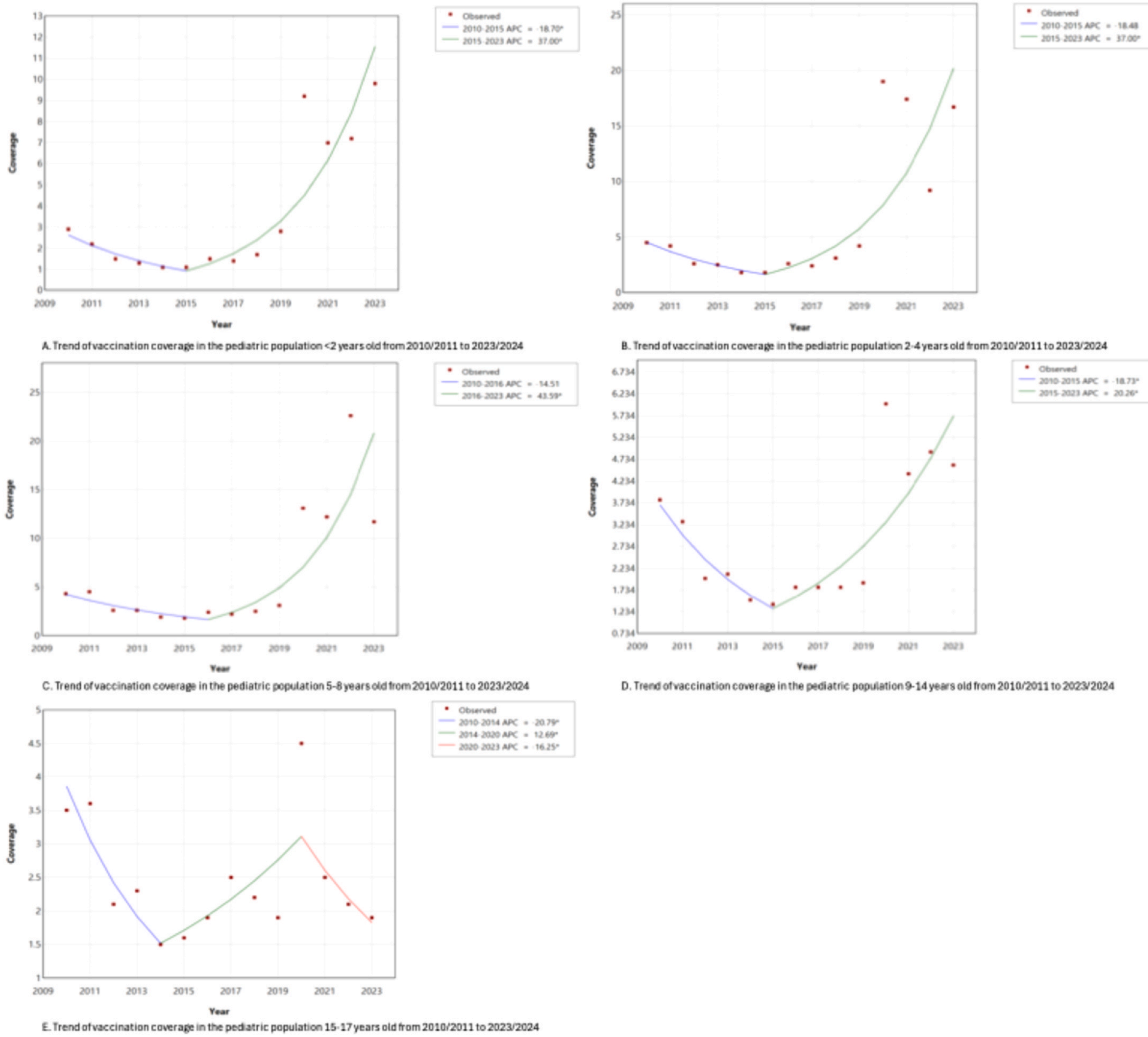

Fig. 2. Trend of vaccination coverage in the pediatric population by age group from 2010/2011 to 2023/2024. The year in the figure corresponds to the season of the same year and the following year. For example, the year 2009 corresponds to the season 2009/2010. *=statistical significance at $p < 0.05$.

Finally, from 2020/2021 to 2023/2024, a decreasing trend is observed (APC=-6.25 %, 95 %CI: −34.06–10.26, p = 0.37). Overall, an increasing AAPC (0.34 %, 95 %CI: −4.11–3.81, p = 0.89) is observed. Also in this age group, coverage reached a higher value in the year of the COVID-19 pandemic. A progressive reduction in coverage was observed in the next three seasons, although the values were higher than in the pre-pandemic period.

Adult population 45–64 years

Coverage ranged from a low of 7.5 % in 2014/2015 to a high of 16.8 % in 2020/2021 (Table 1). Joinpoint analysis showed an initial trend from 2010/2011 to 2014/2015 characterized by a significant reduction in coverage (APC = −12.40 %, 95 %CI: −31.21 to −1.44, p = 0.01), followed by a significative increase until 2023/2024 (APC = +7.43 %, 95 %CI: 3.62–19.26, p = 0.0012) (Fig. 3B and Table 2). The AAPC highlighted a non-significant increase of +0.89 % (95 %CI: −2.07–4.20, p = 0.46) (Table 3). After the pandemic, coverage decreased, reporting, however, higher values than in the seasons prior to 2020.

Elderly population (≥65 years)

The lowest coverage was observed in 1999/2000 (40.7 %) while the highest in 2005/2006 (68.3 %) (Table 1). The analysis highlights 5 joinpoints (Fig. 4 and Table 2). In the first interval, from 1999/2000 to 2003/2004, a significant increase in coverage was reported (+10.75 %, 95 % CI: 7.53–18.44, p = 0.0000). Subsequently, from 2003/2004 to 2009/2010, coverage continued to increase, albeit with a not significant trend (APC = +0.02, 95 %CI: −1.53–1.96, p = 0.95). Then, from 2009/2010 to 2015/2016 a significant decrease of coverage was reported, with an APC of −5.16 % (95 %CI: −9.53 to −3.77, p = 0.0024). Then, the trend increased significantly in the interval from 2015/2016 to 2020/2021, with an APC of +4.91 % (95 %CI: 2.96–10.09, p = 0.0028). In the last interval from 2020/2021 to 2023/2024, a significant downward trend was observed, with an APC of −4.29 %

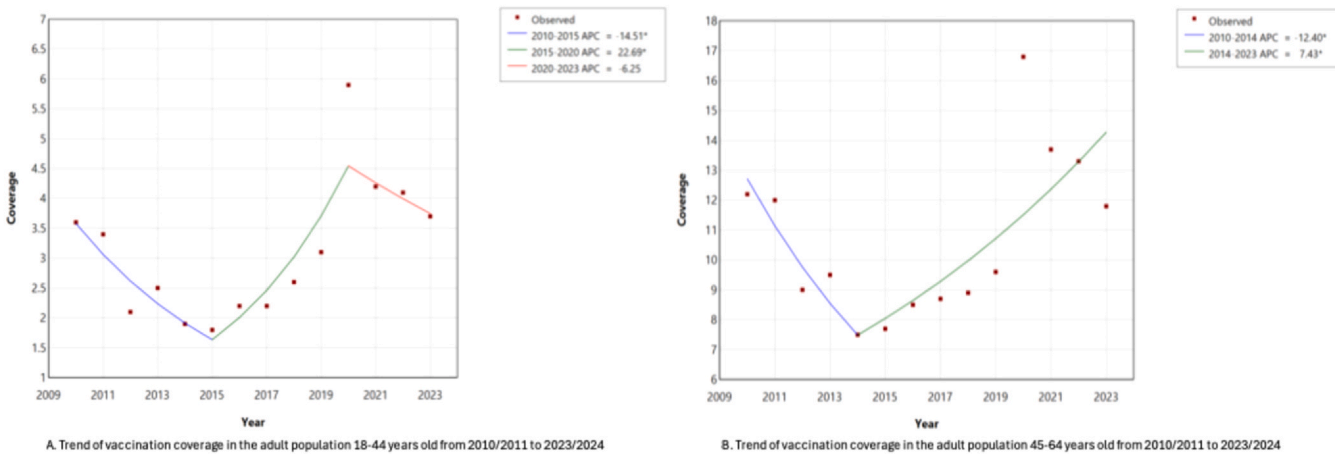

Fig. 3. Trend of vaccination coverage in the adult population by age group from 2010/2011 to 2023/2024. The year in the figure corresponds to the season of the same year and the following year. For example, the year 2009 corresponds to the season 2009/2010. *=statistical significance at p < 0.05.

(95CI%: −10.57 to −1.24, p = 0.0048). Overall, there was a significant increase in coverage, with an AAPC of +0.83 % (95 %CI: 0.35–1.44, p = 0.003) (Table 3).

Discussion

Our study describes trends in influenza vaccination coverage in Italy by age group from 1999/2000 to 2023/2024. In particular, the analysis shows low adherence to influenza vaccination among the population, albeit with differences by age group. In fact, despite the proven efficacy and safety of vaccines [22], coverage never reaches the recommended minimum coverage of 75 % and the optimal value of 95 % in elderly and at-risk populations [23,24]. Similarly, coverage in the general population remains low, with values never exceeding 25 %.

This data aligns with recent European trends, where vaccination coverage often falls short of targets. The ECDC's survey confirms that most European countries have struggled to meet these targets in the past three years, with only minor fluctuations. Compared to southern European countries like Spain and Portugal, Italy reports lower rates of vaccination for > 65, as Portugal surpassed 65 % and met the target in 2020/21. Similarly, northern countries such as Ireland, Sweden, Norway, Finland, and Denmark generally exceed 65 %. Italy performs similarly to central European nations like France (57 %, 54 %, and 56 % in 2020–22), Germany (43 % in 2020), and Luxembourg (< 50 %) [11]. In Italy, persistent low vaccination uptake is linked to distrust and lack of awareness, a long-standing issue, and while the pandemic temporarily boosted coverage, Italy still lags behind countries like Spain and Norway, where hesitancy is more linked to perceived lack of necessity than distrust [25–27]. In Italy, the vaccination is offered free of charge to specific population groups. Although the Ministry's circulars are updated annually, the inclusion criteria for receiving the vaccination free of charge remain largely unchanged, and include, among others, age over 65 (since the pandemic it has been lowered to 60), pregnant women, people with frailties and chronic diseases, children aged 6 months - 6 years, healthcare workers and workers in other sectors considered to be at risk [28].

Several studies have shown that vaccination, both in healthy and at-risk populations, can significantly reduce the risk of death and complications [29–32], as well as reduce the occurrence of major diseases, representing a key tool to protect the health of the population. Likewise, vaccination reduces viral spread, with an important economic impact on society [33]. For example, vaccination of

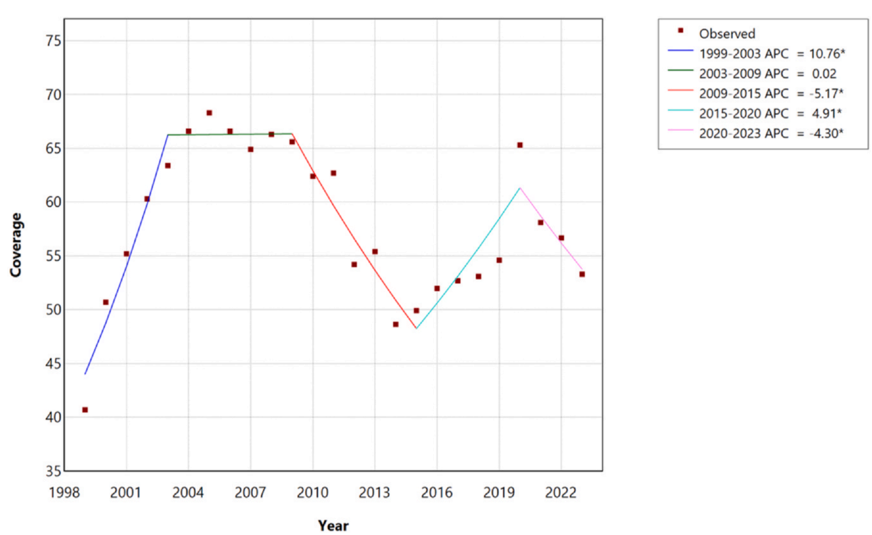

Fig. 4. Trend of vaccination coverage in the elderly population from 1999/2000 to 2023/2024. The year in the figure corresponds to the season of the same year and the following year. For example, the year 1999 corresponds to the season 1999/2000. *=statistical significance at p < 0.05.

children has been shown to significantly reduce hospitalizations, as well as direct costs related to caregiving, and indirect costs related to absenteeism from work and subsequent loss of productivity of parents [7]. Our analysis of children and adolescents is, however, limited to data from 2010 onward even if the low vaccine uptake observed aligns with previous findings in Italy and other European countries. For example, during the 2006/07 and 2007/08 seasons, uptake was below 20 % in eleven European countries, including Italy [34]. While vaccination behaviors may have evolved due to changing public health policies and parental attitudes, historical data to confirm this is lacking. Despite efforts since 2000 to expand vaccination programs and reassure parents, our data show that coverage has remained low in the last fifteen years [35–37].

Several elements may explain the fluctuating and, in any case, always suboptimal coverage trends, with extremely low values for some age groups (for children < 2 years old, coverage never exceeds 10 %, and before the COVID-19 pandemic it was stably between 1 % and 2 %). Various cultural, political, communicational, and scientific factors, in fact, can cause distrust and skepticism about vaccination, fueling vaccine hesitancy [38–40]. Other factors, however, such as health emergencies, can lead to increases or decreases in coverage for specific vaccinations [41–44]. For example, our study shows that during the 2012/2013 season, a decline in coverage is observed in all age groups (-42.5 % in children 5–8 years old, −13.6 % in the population > 65 years old, and −16.3 % overall), and similarly in the 2014/15 season (-26.9 % in children 5–8 years old, −12.28 % in the population > 65 years old, and −12.8 % overall), when the “Fluad Case” happened. In both cases a withdrawal of vaccine batches from the market happened. While official health authorities communicated that the withdrawal was precautionary, media coverage and public perception may have amplified fears, leading to a broader loss of confidence in influenza vaccination [45,46].

These events might have had a negative impact on the vaccination campaign, increasing distrust and fear of a type of vaccination usually perceived as less important [47–49].

Another point to be made is regarding the Italian economic crisis and austerity during the period between 2010 and 2015. As well documented, the austerity policies led to significant budget reductions in public health spending, decreased access to healthcare services, and lower influenza vaccination rates among the general population and the elderly in Italy [50–52].

On the other hand, events such as public health emergencies, and specifically COVID-19, can impact vaccination coverage [42,53–55] both positively and negatively, so much so that our study shows increases in all age groups, with peaks of +322 % in children 5–8 years, +19.6 % in the over-65s, and +41.1 % in the general population. During the COVID-19 season the awareness and perceived risk regarding respiratory infections and their potential severity increased, leading to a better understanding of the importance of vaccination. These increases, which could be linked to the fear of infection and co-infection, can also be attributed to the public health measures implemented: among them, free influenza vaccination might have especially contributed to the pediatric population [14]. Furthermore, during the pandemic, large-scale public health campaigns were heavily funded by the Italian Ministry of Health, including traditional media, social media, advertising, and the involvement of public figures as testimonials. Finally, the coadministration of the influenza and COVID-19 vaccines also facilitated higher uptake of both vaccines [56–58].

However, as the analysis showed, after COVID-19, coverage plummeted again, in many cases to the same pre-pandemic values. This scenario highlights how the belief related to the usefulness of influenza vaccination has failed to take root, although in some age groups coverage has declined but remains higher than pre-pandemic values [59].

The results presented in our study highlight the need for targeted public health actions. Among these, proper communication and information to the population play a key role. For example, the Ministry of Health has organized various campaigns to increase vaccination uptake, such as the “Flu Fighters” campaign by the ISS and “Influenza nelle scuole: prevenire è proteggere” by SIP for children. In addition to the institutional level, healthcare workers (HCWs) also play a key role in patient communication and health education [48].

Often, HCWs express doubts about the usefulness of influenza vaccination, highlighted by low coverages among this population in Italy [60–65]. This evidence is alarming, considering the HCWs key role in increasing awareness and convincing the population to vaccinate [66–68]. It is essential to implement specific training programs for HCWs, starting as early as university courses, to increase awareness and knowledge [65,69,70].

Another key factors to be kept in consideration, is the spread of misinformation and fake news related to vaccination. Studies have shown that misinformation on social media can significantly affect public sentiment and behavior, leading to decreased vaccine acceptance. During the pandemic, this phenomenon was exacerbated, highlighting the importance of reliable information sources, since false claims and fake news ref spread via social media lead to an “infodemic crisis” [71–75]. Also, historically in Italy the contrasting political communication and misinformation has caused public disorientation, leading to fluctuating opinions and behaviors regarding vaccination [76]. Additionally, regional disparities in Italy affect vaccination access and trust, with northern Italy having better healthcare infrastructure and a general better vaccine health literacy, when compared to southern Italy regions [77,78].

A key public health action is to promote policies that can boost vaccination adherence. As demonstrated by the successful COVID-19 vaccination campaign, higher coverage rates are achievable, and vaccination campaigns, similar to the successful COVID-19 campaign, should be funded annually. Furthermore, the extension of free vaccination, implemented during the COVID-19 pandemic, proved to be an important factor. However, despite its relevant achievements, this initiative has not been replicated, even if the evidence that the costs associated with influenza each year far exceed those associated with extending free vaccination [79–81]. Direct and indirect costs for influenza are, indeed, high and significantly impact the healthcare systems [82,83]. Influenza vaccination is proven to be a cost-effective measure and extending free vaccination to all could be beneficial in both health and economic terms [84]. In any case, it is appropriate to continue to assess, through HTA methodologies, the overall impact of vaccination in order to provide evidence to policymakers and guide health policies [85].

Another favorable factor could be the implementation of vaccination campaigns in schools, aiming to increase pediatric vaccination coverages. Such interventions, while challenging, have shown good effectiveness in increasing coverage and parental confidence in vaccination [86–89]. Similarly, other onsite interventions, such as in hospitals or workplaces, could help reduce hesitancy and increase coverage [90]. Another important factor is related to the method of administration, especially in the pediatric population, which has shown the lowest coverages, despite the serious complications related to influenza and the related health and economic impact in this population. In the context, it is necessary to favor the choice of vaccines whose administration can be well tolerated, such as intranasal vaccines, which have demonstrated efficacy and safety not inferior to other vaccines [91].

Increasing influenza vaccination uptake in Italy requires a multifaceted approach. The Italian Ministry of Health, alongside the Istituto Superiore di Sanità (ISS) and regional health offices, should enhance vaccination campaigns through joint communication efforts and targeted public awareness initiatives. Educational programs should begin in schools, offering free flu vaccines to children to foster a culture of vaccination and promote herd immunity.

Healthcare workers play a pivotal role, yet many remain vaccine hesitant. Mandatory flu vaccination for healthcare professionals, along with targeted training programs, would strengthen their commitment and influence public trust.

To counter misinformation, national awareness campaigns should leverage social media and public figures to reach specific populations. Ensuring greater accessibility is also crucial, particularly in rural areas. Mobile vaccination units, pharmacy-based services, and dedicated vaccination days—like those used during the COVID-19 pandemic—would reduce barriers and make vaccination more convenient.

Finally, enhancing patient-doctor communication is essential. Healthcare professionals should be equipped to address concerns and provide accurate information, reducing hesitancy and misinformation. A coordinated effort across institutions, healthcare workers, and public outreach initiatives will be key to improving Italy's influenza vaccination coverage.

Strengths and limitations

Our study has several strengths. It covers 25 years of influenza vaccination campaigns, providing a snapshot of the evolving trends in flu vaccine uptake. Our study also offers an age-stratified trend analysis, highlighting disparities between age groups, and assess the impact of the COVID-19 pandemic on vaccination coverage. Furthermore, our results confirm Italy's consistently low coverage, which has never reached the 75 % target across all groups, particularly among high-risk populations such as those over 65. Our study has some limitations. First, in some cases coverage data for age groups are missing. However, as the source of the data is the Ministry of Health, it is not possible to retrieve information for the missing seasons. In addition, despite the lack of these data, there is still a time span of 13 years, which provides an indication of trends. Then, the joinpoint analysis allows us to describe the trends but not to make any causal relation, even though this methodology has already been used in the vaccination field. Finally, we were not able to stratify coverage by at-risk populations. Such data, in fact, would provide insights into the percentage of the vaccination-indicated population that is vaccinated, compared with the healthy population. The lack of stratification at the national level could be overcome with studies conducted locally but still representative of the population, to provide an indication to policymakers about the effectiveness of vaccination campaigns in reaching target populations.

Conclusion

Our study highlights how vaccination coverage in Italy, both in the general population and by age group, remains low over the years and below the threshold set by the WHO. In this context, trend analysis is fundamental to describe the situation and promote targeted public health actions aimed at increasing vaccine adherence in the population. The Italian Ministry of Health, along with the Istituto Superiore di Sanità and regional health offices, should collaborate to improve vaccination campaigns. Increasing knowledge about the importance of influenza vaccination among HCWs and citizens, fostering targeted campaigns in specific population groups, and implementing policies such as extending free vaccination in the entire population are public health recommendations that could increase vaccination coverage in Italy.

Author contributions

All authors contributed to the study conception and design. LV conceived the research hypothesis. Material preparation and data collection were performed by LV, AZ, LR, MB and TS. MB, AZ, LR, and LV performed statistical analysis. The first draft of the manuscript was written by AZ, LR, MB, and LV. WR, SB, TS and AS commented on the latest version of the manuscript. LV supervised the study. All authors read and approved the final version of the manuscript.

Ethical approval

Not applicable.

Funding

The authors declare they have not received funding to conduct this study.

Data availability

The data are obtained from the Italian Ministry of Health and are public and free.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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