HUMAN VACCINES & IMMUNOTHERAPEUTICS
2025, VOL. 21, NO. 1, 2493027
https://doi.org/10.1080/21645515.2025.2493027

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RESEARCH ARTICLE

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Assessing vaccine coverage and delivery strategies for influenza and COVID-19 among Italian healthcare workers: A 2015–2023 case study

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ABSTRACT

Healthcare workers (HCWs) are essential in preventing and managing infectious diseases. Despite their critical role, vaccination coverage among HCWs remains suboptimal, endangering not only patient safety and healthcare system efficiency, but also HCWs' own health due to their frequent exposure to infectious agents. This study examines a decade of influenza vaccination trends and recent COVID-19 vaccine co-administration patterns at a major Italian hospital, aiming to identify factors affecting vaccine acceptance and evaluate organizational strategies to enhance vaccination uptake. A retrospective cohort study analyzed vaccination data from 6,341 hCWs between 2015 and 2023, examining acceptance rates across different vaccination delivery models. Mixed effects logistic regression models evaluated the impact of sociodemographic and professional factors and organizational approaches on vaccine acceptance. Results showed influenza vaccination peaked at 46% during the first COVID-19 year, before declining to pre-pandemic levels. Co-administration rates increased significantly, with a 118.94% rise between 2021 and 2022. Different delivery models significantly influenced vaccine acceptance: "open-day" events significantly boosted influenza vaccine acceptance (OR 22.29, 95% CI [18.22; 27.27]), while the hospital outpatient service proved optimal for co-administration (OR 61.03, 95% CI [30.97; 120.25]). This study reveals important patterns in vaccination behavior and organizational effectiveness. The observed decline in influenza vaccination after the COVID-19 peak suggests vaccine fatigue and reduced risk perception due to widespread preventive measures. The success of different delivery models indicates that healthcare institutions should implement multiple, complementary vaccination strategies tailored to specific contexts and workforce preferences, while maintaining continuous educational support to ensure sustained vaccine coverage.

ARTICLE HISTORY
Received 2 December 2024
Revised 28 March 2025
Accepted 10 April 2025

KEYWORDS
Influenza vaccines; COVID-19 vaccines; vaccination coverage; health personnel; immunization programs

Introduction

Healthcare workers (HCWs) are essential to public health, as they are directly involved in preventing, diagnosing, and treating diseases.[1] Their frequent contact with patients and infectious materials increases their risk of acquiring and potentially spreading infections to vulnerable patients,[2–4] making their protection through preventive measures crucial for both their health and healthcare quality.[2,5,6]

Vaccination, recognized as one of the most cost-effective public health interventions,[7] plays a fundamental strategic role at the national level in pandemic preparedness and response. Historically, large-scale coordinated vaccination campaigns have proven to be decisive tools in containing infectious diseases, significantly contributing to the reduction of morbidity and mortality during pandemic events.[8,9] In healthcare settings, vaccination offers multiple benefits: it reduces disease transmission, protects high-risk patients[2,6] and decreases HCW absenteeism and related costs due to productivity loss.[10–12] Moreover, vaccinated HCWs are more effective advocates for vaccination,[2,13] with research showing their strong influence on public vaccination adherence.[14–18]

Despite these advantages, HCW vaccination rates remain suboptimal, often falling below the World Health Organization's 75% target for influenza vaccination,[19,20] raising concerns about infection control in healthcare settings.[21,22] This trend is particularly concerning given the temporary increase observed during the 2020 influenza season, when the absence of a SARS-CoV-2 vaccine led to higher vaccination rates among HCWs.[21,23,24]

The reasons behind low vaccine uptake among HCWs are complex and influenced by multiple factors,[25–27] from underestimation of disease severity and concerns about vaccine safety to practical barriers such as limited access and time constraints.[27–31] The type of profession and healthcare setting also influence vaccination rates.[28]

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/21645515.2025.2493027

This hesitancy is particularly significant given HCWs' role as public health models,[32] as highlighted during the COVID-19 pandemic, where despite increased influenza vaccination rates,[23,33,34] COVID-19 vaccine acceptance varied considerably.[35–38]

Healthcare institutions have developed multiple strategies to address these challenges. Educational programs aimed at improving vaccine knowledge and correcting misinformation have shown effectiveness in changing attitudes.[39–44] Access enhancement through on-site vaccinations, mobile units, and extended hours has proven equally important.[27,39,45] Dedicated hospital-based vaccination centers have emerged as successful organizational models, offering integrated services, personalized advice, and logistical support. These centers create environments where various vaccination strategies can be effectively implemented, while initiatives like "vaccination open days" enhance engagement by increasing visibility and fostering a supportive atmosphere that promotes participation.[46]

Additionally, co-administering vaccines – giving two or more vaccines at different sites in a single visit – is a promising strategy, as it reduces missed opportunities and promotes timely immunization.[47–49] Originally established in pediatric and travel medicine, this approach has proven effective for adult vaccination programs[50,51] with simultaneous influenza and COVID-19 vaccination demonstrating both safety and improved compliance.[52–54]

Although existing literature has extensively documented the factors influencing vaccine hesitancy among HCWs and various intervention strategies, important gaps remain in understanding the comparative effectiveness of integrated approaches in real-world settings. The experience gained during the COVID-19 pandemic has highlighted the importance of dedicated facilities and flexible protocols capable of rapidly adapting to the evolving epidemiological context.[9]

The aim of this study is to evaluate trends in influenza vaccination coverage and in the acceptance of co-administration of influenza and SARS-CoV-2 vaccines among healthcare workers at the Fondazione Policlinico Universitario "A. Gemelli" IRCCS (FPG), in Rome, and to identify the factors that influenced this acceptance, with a specific focus on different vaccination delivery models as a key influencing factor.

The secondary aim of the study is to perform sub-analyses to identify the determinants of influenza vaccination acceptance pre- and post-COVID-19, without considering the type of vaccine offering.

Materials and methods

Sample and data

A retrospective panel data cohort study was conducted to evaluate trends in influenza vaccination coverage and acceptance of influenza and anti-SARS-CoV-2 vaccination co-administration among the HCWs of the FPG, an Italian high complexity research hospital based in Rome. All personnel were offered vaccination by the Hygiene Unit of the hospital, during the vaccination campaigns from 2015 to 2023.

All healthcare workers and administrative staff at the hospital units of FPG, who provided written informed consent, were included in the study. During each annual campaign, participants were asked to sign a consent form that authorized both the administration of the vaccine and the use of their data for research purposes. The study protocol was regularly reviewed, updated, and amended each year.Information on vaccination campaigns, such as age, gender, type of vaccine administered, vaccination date, professional category, was recorded by vaccinating physicians and entered into the hospital's data warehouse through a data entry interface by administrative personnel. The datasets related to the vaccination campaigns for healthcare workers were obtained from the data warehouse services of the FPG for the years 2015 to 2023. A separate dataset was created by assigning an anonymous identifier to each individual to ensure pseudonymization.

Socio-demographic data, such as age and gender, were retrieved using the individual employee tax code, while occupation-related data were acquired from the hospital's human resources unit. A comparison was conducted with the vaccination registry databases of the Lazio Region to determine if any subjects who had not been vaccinated during the campaigns had received vaccinations at other clinics or hospitals. These individuals were excluded from the analysis.

Additionally, subjects who were not present during all the analyzed years were also excluded.

The study protocol was approved by the Ethical Board Lazio Area 3 with the approval number 00444/23 ID 3706.

Vaccination campaigns

The vaccination campaigns for healthcare workers at the FPG from 2015 through 2023 were considered in this study. All vaccination campaigns, held between October and December of each year, were organized by the Hospital Hygiene Unit in collaboration with the Health Management Unit. Each campaign included a dissemination phase, involving posters and institutional e-mails to promote participation. The anamnesis evaluation of the healthcare workers were conducted by physicians from the Hospital Hygiene Unit, as well as by resident physicians specializing in Hygiene and Preventive Medicine at Università Cattolica del Sacro Cuore in Rome. The administration of vaccines was carried out by hospital nurses. The vaccination administration methods varied according to the campaign:

- **2015**: Opportunistic vaccinations without a dedicated vaccination service. Vaccines were supplied to various services, including occupational health and preventive medicine, but without an active offer. Administration was carried out only in the mornings on weekdays, either upon request or during medical visits, without a structured booking system.
- **2016, 2017, 2018, 2019**: On-site vaccination service and dedicated room for vaccinations available during the week. The on-site involved two trained medical residents visiting hospital wards to provide influenza vaccination counseling and administer vaccines to HCWs on a voluntary basis. Sessions were scheduled in advance with unit directors and nurse coordinators, with reminders sent beforehand. The dedicated vaccination room was used exclusively during the three-month campaign,

operating on weekdays for three hours a day, but without a structured booking system.[43]

- **2020**: Dedicated room for vaccinations available during the week. The dedicated vaccination room was used exclusively during the three-month campaign, operating on weekdays for three hours a day, but without a structured booking system or a coordinated plan.
- **2021**: Hospital vaccination hub established in response to the COVID-19 emergency, open 7 days a week. Due to the pandemic emergency, the Lazio region requested the opening of a hospital vaccination hub in our facility for the administration of SARS-CoV-2 vaccines, operating 12 hours a day, 7 days a week for external users. This center was also used to vaccinate healthcare workers against both influenza and SARS-CoV-2, ensuring access through a structured internal booking system.
- **2022**: Ten "open day" vaccination events held on Fridays and Saturdays. An "open day" is a vaccination event designed to provide easy and direct access to immunization without the need for an appointment. Unlike the dedicated vaccination room, these events allowed for significantly higher vaccination volumes, thanks to the deployment of additional personnel and resources. Each session lasted up to 8 hours, with the capacity to administer up to 1,000 vaccinations per event, ensuring efficient and large-scale immunization.
- **2023**: Outpatient vaccination service operating mornings and afternoons on weekdays. In collaboration with the Lazio Region and the Local Health Authority (ASL Roma 1), an outpatient vaccination service was established within our hospital, operating on weekdays with dedicated medical and nursing staff and a structured organizational framework to ensure efficient access. During the vaccination campaign, two afternoons per week were specifically reserved for healthcare workers, who could receive their vaccinations by appointment.

Table S1 organizes vaccination activities by year, grouping them into clear and comparable patterns.

The vaccines were provided free of charge following an agreement between the hospital and the local health authority ASL Roma 1. The influenza vaccines included trivalent or quadrivalent vaccines, with or without adjuvants. Adjuvanted vaccines were administered to individuals over 65 years of age. Inactivated quadrivalent vaccines with surface antigens prepared in cell cultures were also used for individuals with egg protein allergies. The vaccines used are listed in Supplementary materials.

The COVID-19 vaccine administered was Comirnaty Original mRNA (Pfizer/BioNTech) during the 2021 campaign, Comirnaty Original/Omicron BA.4–5 mRNA during the 2022 campaign, and Comirnaty XBB 1.5 mRNA during the 2023 campaign.

Co-administration was defined as receiving both the influenza and COVID-19 vaccines during the same vaccination session and was offered to all healthcare workers starting from the 2021 vaccination campaigns onward.[53]

It was decided to consider only influenza vaccinations and their co-administration with the COVID-19 vaccine, as both of these outcomes reflect healthcare workers' willingness to receive vaccination. This is in contrast to COVID-19 vaccine coverage, which was heavily influenced by the mandatory vaccination policies implemented during the COVID-19 pandemic.

Models and data analysis procedure

Descriptive and dispersion statistics were calculated for each variable. Variables with non-normally distributed sample means were divided into classes, using quartiles as class limits. The co-administration variable accounted for all subjects who received both vaccines during the same vaccination session, compared to those who received the two vaccinations separately.

A categorical variable was created to account for the differences in the type of vaccination offering. For each professional category, influenza vaccination and co-administration acceptance were respectively compared between each vaccination campaign and the previous one using the McNemar Test or the Exact McNemar Test, when the number of events was small.

Two different mixed effects logistic regression models were created, with a random intercept at the level of the healthcare worker.

The first model had as outcome the acceptance of influenza vaccination, the second one the acceptance of co-administration of influenza and COVID-19 vaccines; both of these models included as predictors gender, professional category, type of vaccination offer and, respectively, age in 2015 and age in 2021.

The year 2020 was excluded from the analysis because the increase in vaccination coverage was influenced more by fear of COVID-19 and the absence of a COVID-19 vaccine than by the type of vaccination offering.

Sub-analyses were conducted by creating two models, one before and one after 2020, in order to identify the determinants of influenza vaccination acceptance pre- and post-COVID-19, without taking into account the type of vaccine provision, which was not comparable, as the types of vaccination centers used were different pre- and post-COVID-19.To assess the goodness of fit of the models, tables of predicted and observed outcomes in each decile of predicted risk were determined, and a plot of the values was produced.

The significance level of the statistical analyses was set at 5%.

The analyses were performed in 2024 and run on STATA 18 (StataCorp LP, College Station, TX, USA).

Results

A total of 6,341 healthcare workers were included in the analysis, of whom 4,000 were women (63.08%) with a median age of 38 years. Among them, 2,243 were nurses (35.37%), followed by physicians (1,572). The sociodemographic characteristics of the sample are described in Table 1.

Figure 1 shows the number of healthcare workers by professional category who received the influenza vaccination during the vaccination campaigns from 2015–2016 to 2023–2024.

Table 2, on the other hand, presents the number of healthcare workers by professional category who received both the influenza

Table 1. Socio-demographic characteristics of the sample analyzed.

Variable		N (%)
Gender	Male	2,341 (36.92)
	Female	4.000 (63.08)
Age in 2015	18–27	1,655 (26.10)
	28–38	1,671 (26.35)
	39–47	1,590 (25.07)
	48–62	1,425 (22.47)
Professional category	Physicians	1,572 (24.79)
	Nurses	2,243 (35.37)
	Other HCWs**	1,302 (20.53)
	Administrative staff	1,224 (19.30)

**The category "Other HCWs" includes midwives, healthcare assistants, pharmacists, psychologists, laboratory technicians, radiology technicians, physiotherapists, speech therapists, perfusionists, neurophysiopathology technicians, biologists, environmental and occupational prevention technicians, dieticians, orthoptists, audiometrists, occupational therapists and neuro- and psychomotricity therapists for children and adolescents.

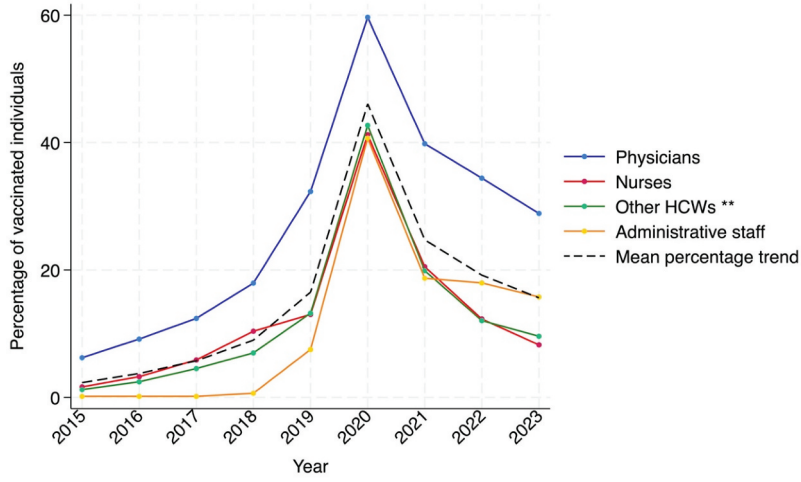

Figure 1. Time-trend of flu vaccination at FPG by professional category. Figure 1 shows the number of HCWs who accepted flu vaccination out of the total HCWs for each year considered. **The category "Other HCWs" includes midwives, healthcare assistants, pharmacists, psychologists, laboratory technicians, radiology technicians, physiotherapists, speech therapists, perfusionists, neurophysiopathology technicians, biologists, environmental and occupational prevention technicians, dieticians, orthoptists, audiometrists, occupational therapists and neuro- and psychomotricity therapists for children and adolescents.

Table 2. Number of co-administrations of flu and COVID vaccinations, and percentage of HCWs at FPG that accepted co-administration compared by professional category.

	Co-administration of vaccines		
Professional category	2021	2022	2023
Physicians	323 (38.27)*	507 (89.89)*	361 (94.75)*
Nurses	192 (43.24)*	137 (87.26)*	57 (93.44)*
Other HCWs°°	120 (48.58)*	60 (82.19)*	41 (91.11)*
Administrative staff	77 (35.65)*	104 (91.23)*	54 (87.10)*
Total n° of HCWs accepting co-administration	712 (40.66)*	808 (88.99)*	513 (93.44)*
Total n° of HCWs	1,751	908	549

For each professional category, co-administration acceptance was compared between each vaccination campaign and the previous one using the McNemar Test or the Exact McNemar Test, as applicable.

*p-values < 0.01.

°°The category "Other HCWs" includes midwives, healthcare assistants, pharmacists, psychologists, laboratory technicians, radiology technicians, physiotherapists, speech therapists, perfusionists, neurophysiopathology technicians, biologists, environmental and occupational prevention technicians, dieticians, orthoptists, audiometrists, occupational therapists and neuro- and psychomotricity therapists for children and adolescents.

and COVID-19 vaccines through co-administration, compared to the total number of workers who received the vaccines separately.

The temporal changes in the number of influenza vaccinations were statistically significant for each professional category. Similarly, the temporal changes in the number of co-administered vaccinations were statistically significant for each professional category.

The multivariable mixed-effects logistic regression model, with acceptance of the influenza vaccination as the outcome, revealed a very strong positive association between influenza vaccination and, respectively, the vaccination delivery model involving a hospital vaccination hub open 7 days a week (OR 38.98, 95% CI [31.87; 47.69]) and "open days" events (OR 22.29, 95% CI [18.22; 27.27]).

A strong positive association was highlighted between flu vaccination acceptance and being a healthcare worker, with the strongest association observed for physicians (OR 34.44, 95% CI [24.01; 49.40]). Nurses also showed a significant positive correlation, while administrative staff had the lowest likelihood of accepting the vaccine (Table 3a).

The multivariable mixed-effects logistic regression model revealed the strongest positive association between co-administration of COVID-19 and influenza vaccines and the hospital outpatient vaccination service offered in the afternoon two days a week (OR 61.03, 95% CI [30.97; 120.25]).

No statistically significant association could be described between co-administration acceptance and professional category; however, strangely, the propensity to accept the coadministration of the influenza and COVID-19 vaccines decreased with increasing age class (Table 3b).

Both of the models appeared to distinguish between higher and lower risk fairly well (the majority of cases are correctly predicted in the higher quantiles), but there were clear discrepancies between predicted and actual values, especially in the extreme quantiles.

As for the analysis conducted by distinguishing before and after 2020, the model with the outcome of influenza vaccination acceptance before 2020 showed a very strong positive association between the latter and the professional category of physicians (OR 20.32, 95% CI [15.06; 27.43]), while the association was strong with the professional category of nurses (OR 7.03, 95% CI [5.20; 9.50]) and the age group 48–62 years (OR 6.63, 95% CI [5.19; 8.50]) (Table 3c).

Nation acceptance after 2020 showed a very strong positive association with having received the COVID-19 vaccine during the same campaign (OR 15.92, 95% CI [13.20; 19.20]). In contrast, the association with doctors (OR 8.24, 95% CI [4.37; 15.55]) and the age group 48–62 years (OR 3.06, 95% CI [1.66; 5.68]), though positive and statistically significant, was notably weaker compared to the pre-pandemic period (Table 3d).

Discussion

This study is among the first to analyze long-term trends in influenza vaccination among HCWs within the same hospital over a decade while assessing the correlation between vaccination uptake and the delivery models implemented. It also evaluated influenza and COVID-19 vaccine co-administration.

Findings showed a steady increase in influenza vaccination, peaking at 46% during the first COVID-19 year, followed by a marked decline back to pre-pandemic levels. Co-administration adherence improved significantly, with a 118.94% increase between 2021 and 2022. Different delivery models influenced vaccine acceptance: Open Days boosted influenza vaccination, while the Outpatient Vaccination Service played a key role in increasing adherence to co-administration. Post-COVID analysis revealed that previously strong associations between professional categories, age, and vaccine uptake thinned out. Instead, the analysis of co-administration acceptance showed a strong persistent tendency among younger HCWs to accept it.

The temporal trend in influenza vaccination coverage closely aligns with findings from the UK Health Security Agency (UKHSA).[55] Their data show a moderate increase before the pandemic, followed by a peak in 2020, likely driven by concerns over COVID-19 and the absence of a vaccine at the time.[23] However, in subsequent years, coverage steadily declined, with a 7.1% point drop in 2022–2023, marking the third consecutive year of decline.[55] This decline can be attributed to vaccine fatigue, as the strong focus on COVID-19 vaccination may

Table 3a. Results of the multivariable logistic mixed-effect regression models in form of odds ratio with 95% confidence interval.

Variable	Odds-ratio	95% CI
Type of vaccination offer		
Opportunistic vaccinations	1	[1;1]
On-site + dedicated room	6.42	[5.31; 7.76]*
Hospital vaccination hub	38.98	[31.87; 47.69]*
"Open days"	22.29	[18.22; 27.27]*
Outpatient vaccination service	14.81	[12.09; 18.14]*
Professional category		
Administrative staff	1	[1;1]
Physicians	34.44	[24.01; 49.40]*
Nurses	9.52	[6.66; 13.62]*
Other HCWs°°	6.12	[4.19; 8.95]*
Gender		
Female	1	[1;1]
Male	0.99	[0.87; 1.13]
Age in 2015		
18–27	1	[1;1]
28–38	2.11	[1.75; 2.54]*
39–47	3.14	[2.61; 3.77]*
48–62	5.35	[4.43; 6.45]*

In the model, the outcome variable is represented by the acceptance of flu vaccination at FPG.

*p-values < 0.05.

°°The category "Other HCWs" includes midwives, healthcare assistants, pharmacists, psychologists, laboratory technicians, radiology technicians, physiotherapists, speech therapists, perfusionists, neurophysiopathology technicians, biologists, environmental and occupational prevention technicians, dieticians, orthoptists, audiometrists, occupational therapists and neuro- and psychomotricity therapists for children and adolescents.

Table 3b. Results of the multivariable logistic mixed-effect regression models in form of odds ratio with 95% confidence interval.

Variable	Odds-ratio	95% CI
Type of vaccination offer		
Hospital vaccination hub	1	[1;1]
"Open days"	29.36	[17.20; 50.12]*
Outpatient vaccination service	61.03	[30.97; 120.25]*
Professional category		
Administrative staff	1	[1;1]
Physicians	0.79	[0.55; 1.14]
Nurses	1.30	[0.87; 1.94]
Other HCWs°°	1.45	[0.92; 2.27]
Gender		
Female	1	[1;1]
Male	1.48	[1.16; 1.89]*
Age in 2021		
18–27	1	[1;1]
28–38	0.54	[0.38; 0.77]*
39–47	0.28	[0.19; 0.41]*
48–62	0.26	[0.18; 0.38]*

In the model, the outcome variable is represented by the acceptance of co-administration of flu and COVID vaccinations at FPG.

*p-values < 0.05.

°°The category "Other HCWs" includes midwives, healthcare assistants, pharmacists, psychologists, laboratory technicians, radiology technicians, physiotherapists, speech therapists, perfusionists, europhysiopathology technicians, biologists, environmental and occupational prevention technicians, dieticians, orthoptists, audiometrists, occupational therapists and neuro- and psychomotricity therapists for children and adolescents.

Table 3c. Results of the multivariable logistic mixed-effect regression models in form of odds ratio with 95% confidence interval.

Variable	Odds-ratio	95% CI
Professional category		
Administrative staff	1	[1;1]
Physicians	20.32	[15.06; 27.43]*
Nurses	7.03	[5.20; 9.50]*
Other HCWs°°	4.80	[3.49; 6.62]*
Gender		
Female	1	[1;1]
Male	1.23	[1.04; 1.46]*
Age in 2015		
18–27	1	[1;1]
28–38	2.74	[2.14; 3.51]*
39–47	4.46	[3.49; 5.69]*
48–62	6.63	[5.19; 8.50]*

In the model, the outcome variable is represented by the acceptance of flu vaccination at FPG before 2020.

*p-values < 0.05

°°The category "Other HCWs" includes midwives, healthcare assistants, pharmacists, psychologists, laboratory technicians, radiology technicians, physiotherapists, speech therapists, perfusionists, neurophysiopathology technicians, biologists, environmental and occupational prevention technicians, dieticians, orthoptists, audiometrists, occupational therapists and neuro- and psychomotricity therapists for children and adolescents.

have reduced enthusiasm for influenza vaccines.[56] Additionally, the widespread use of non-pharmaceutical interventions (e.g., mask-wearing, distancing) during the pandemic significantly lowered influenza transmission, leading to a reduced perceived risk and lower vaccination motivation.[56,57] A similar trend was observed in Italy, where HCW vaccine acceptance rose from 12% pre-pandemic to 59% in 2020, before dropping to 37% in 2021, reflecting waning preventive awareness.[58] Likewise, in China, HCW influenza vaccination rates declined post-pandemic due to reduced perceived risk.[59] Across Europe, ECDC data indicate a continued decline in HCW vaccination rates.[21] Similarly, the CDC in the United States reported decreasing HCW coverage, reinforcing the need for sustained immunization efforts.[60]

To date, no studies have analyzed the long-term trend of vaccine co-administration. The only available data on HCWs come from Stefanizzi et al., reporting a 64.76% adherence rate among HCWs in 2021 at Bari Policlinico General Hospital, the first year this option was introduced.[61] The growing adoption of co-administration is driven by its confirmed safety and logistical benefits. Trust in official recommendations and the convenience of reducing healthcare visits are key factors influencing acceptance.[62] This approach not only alleviates pressure on healthcare systems but also ensures safety and maintains immune response,[63–66] with no increased risk of SARS-CoV-2 breakthrough infection. Additionally, co-administration may enhance SARS-CoV-2 neutralizing antibody responses while preserving robust protection against influenza.[65] Therefore,

Table 3d. Results of the multivariable logistic mixed-effect regression models in form of odds ratio with 95% confidence interval.

Variable	Odds-ratio	95% CI
Professional category		
Administrative staff	1	[1;1]
Physicians	8.24	[4.37; 15.55]*
Nurses	1.25	[0.67; 2.33]
Other HCWs**	1.14	[0.60; 2.16]
Gender		
Female	1	[1;1]
Male	0.89	[0.68; 1.16]
Age in 2021		
18–27	1	[1;1]
28–38	1.06	[0.57; 1.98]
39–47	1.31	[0.71; 2.42]
48–62	3.06	[1.66; 5.68]*
COVID vaccination received in the same vaccination campaign		
No	1	[1;1]
Yes	15.92	[13.20; 19.20]

In the model, the outcome variable is represented by the acceptance of flu vaccination at FPG after 2020.
*p-values < 0.05.
**The category "Other HCWs" includes midwives, healthcare assistants, pharmacists, psychologists, laboratory technicians, radiology technicians, physiotherapists, speech therapists, perfusionists, neurophysiopathology technicians, biologists, environmental and occupational prevention technicians, dieticians, orthoptists, audiometrists, occupational therapists and neuro- and psychomotricity therapists for children and adolescents.

this trend could be justified by the fact that, despite the decline in overall vaccine coverage, those who continue to get vaccinated do so by opting for co-administration in light of the aforementioned advantages, leading to a relative increase in the percentage of adherence to this practice.

By analyzing different delivery models for influenza vaccine acceptance, this study explored a largely unexamined area. No studies compare delivery models over time for healthcare workers. The only available data pertain to hospital-based experiences from some Italian hospitals implementing onsite vaccination, which – consistent with our findings – has proven to be effective but is always combined with additional incentive strategies and requires substantial resources, making large-scale implementation challenging.[67]

While onsite vaccination had a positive effect, logistic regression analysis showed an even stronger association for models that enhanced accessibility and reduced logistical constraints, notably the open 7-day model and "open day" vaccination events. However, the open 7-day model emerged as an outlier, likely due to its extended availability and the lingering effects of COVID-19, which may have influenced vaccine uptake. In contrast, "open day" events played a crucial role in increasing participation rates by offering greater convenience, leveraging peer influence, and creating a sense of urgency.[68] Their walk-in flexibility and short-term nature make them an effective delivery model for influenza vaccines, particularly in settings where social visibility and group participation encourage attendance.[69] On the other hand, hospital outpatient service, with structured environments, booking systems, and post-vaccination monitoring, are probably more conducive to co-administration of influenza and COVID-19 vaccines. These services provide a controlled atmosphere that fosters patient safety, reduces anxiety, and allows for proper monitoring of any potential side effects, particularly in more vulnerable populations.[70]

Although the pre- and post-COVID sub-analysis highlighted a reduction in the differences that previously existed among professional categories and age groups regarding flu vaccine acceptance, a higher uptake propensity remains among physicians and older age groups. These findings, along with their underlying motivations – such as elevated education levels among physicians and increased awareness of risks among older people – are widely documented in the literature.[20,71–74] The greater inclination of younger healthcare professionals toward co-administration appears atypical yet intriguing. Only three studies have examined this phenomenon, yielding contrasting results. Kenigsberg et al. reported higher acceptance among older age groups,[75] while Stefanizzi et al., focusing solely on healthcare workers, found no correlation.[61] Conversely, Dominich et al., in a survey of the Italian population, observed a slight decline in co-administration acceptance with increasing age,[76] suggesting younger individuals were more inclined to accept it. This was attributed to older adults' tendency to adopt a more cautious approach toward new healthcare practices. This phenomenon should be further investigated.

Theoretical implications

This study contributes to the literature on vaccine uptake by examining the long-term trends in influenza vaccination and co-administration among HCWs, as well as the impact of different delivery models. While previous research has focused on general vaccine acceptance, our findings highlight how structural and organizational factors significantly influence adherence. The results align with behavioral theories such as the Health Belief Model (HBM) and Planned Behavior Theory, reinforcing that institutional trust and convenience play key roles in vaccination decisions.[77] As reported in the literature, one of the most common reasons for vaccine refusal among HCWs is concern about availability,[78] and this study has reinforced the hypothesis that improving accessibility and enhancing organizational capacity increase compliance. Furthermore, promoting safe and effective practices, such as vaccine co-administration, further optimizes the process by minimizing multiple appointments and increasing overall adherence, particularly during critical periods like flu season.

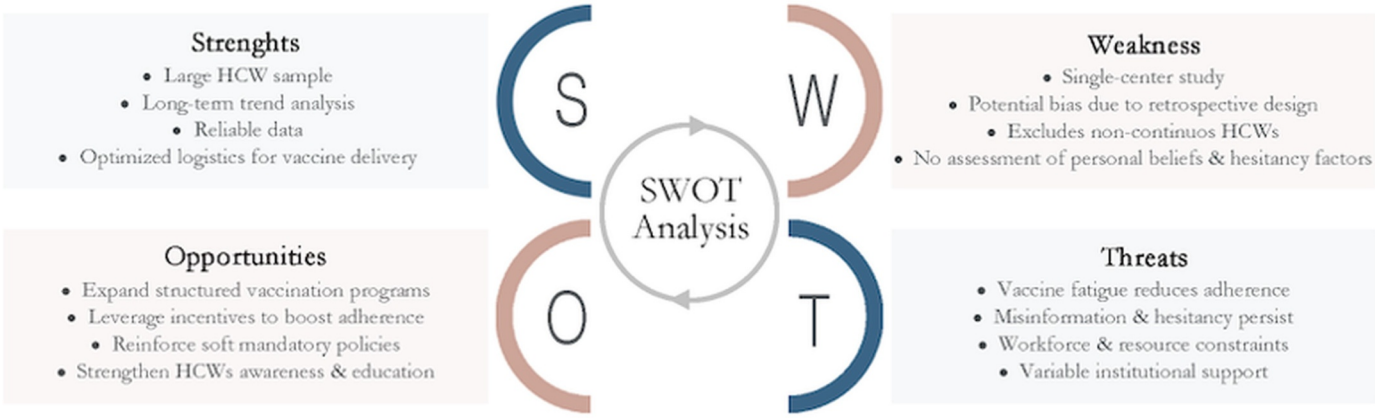

Figure 2. SWOT analysis.

Policy and managerial implications

Effective vaccination strategies require a comprehensive understanding of the factors influencing vaccine uptake among HCWs. Identifying these key determinants allows organizations to develop targeted interventions aimed at increasing coverage, particularly among hesitant subgroups. Hospitals should integrate vaccination into occupational health policies, offering systematic workplace access to influenza and COVID-19 vaccines while implementing pre-scheduled co-administration protocols to enhance adherence and optimize resources. Furthermore, increasing HCWs' awareness of the benefits of vaccination not only fosters better patient education but also strengthens public trust in vaccination programs. To sustain these efforts, a coordinated commitment from policymakers, healthcare managers, and medical directors at the macro, meso, and micro levels is needed to reinforce institutional engagement and invest in vaccination infrastructure, ensuring the resilience of healthcare systems and safeguarding both HCWs and patients.

Strengths and limitations

One limitation of the study is that the data was collected from a single hospital in Italy, which may affect the generalizability of the findings to other regions or settings with different healthcare systems. However, the inclusion of a large sample of 6,341 healthcare workers from a high-complexity hospital strengthens the study by allowing detailed analysis across professional categories and age groups, thereby increasing the robustness of the results. The retrospective design may introduce biases in data collection and accuracy, but systematic vaccination data collection and integration with regional registries ensure high reliability. Another limitation is the exclusion of HCWs with sporadic employment since only continuously employed staff from 2015 were analyzed, potentially affecting coverage estimates. Additionally, vaccinations received outside our hospital were not considered, which could further influence the reported coverage rates. Nonetheless, the multi-year dataset provides valuable insights into long-term trends. Finally, the study did not account for confounding factors such as personal beliefs levels of education, yet rigorous statistical analysis and alignment with existing literature enhance its credibility.

Further issue

To improve the generalizability of these findings, future research should validate results across diverse healthcare settings. Incorporating qualitative data on healthcare workers' attitudes and motivations, as well as investigating potential confounding factors such as personal beliefs, could provide deeper insights into vaccine acceptance and hesitancy.

Further studies should explore whether nudging interventions or incentive systems (e.g., workplace benefits, professional credits, or recognition programs),[43,79] can enhance vaccination coverage when integrated with tailored delivery strategies. Additionally, the potential impact of soft mandatory vaccination policies and targeted communication strategies,[80] which have been widely discussed in the literature, should be assessed in combination with these models.

To further contextualize these findings, a SWOT analysis (Figure 2) summarizes the strengths, weaknesses, opportunities, and threats associated with the different vaccination models.

Conclusion

Influenza vaccination among HCWs peaked during the first COVID-19 year before declining, reflecting global trends, while adherence to co-administration increased significantly. 'Open Day' events proved the most effective strategy for increasing influenza vaccination uptake, whereas the Outpatient Vaccination Service facilitated co-administration. The findings suggest that diverse vaccination delivery models influence uptake patterns differently, emphasizing the need for tailored approaches to maintain high coverage and long-term adherence among HCWs. Future research should explore whether combining optimized logistical strategies with behavioral interventions could further enhance vaccine acceptance and sustain coverage across different healthcare settings.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The author(s) received no specific funding for this work.

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Data availability statement

The data are available upon request. All requests were addressed by the corresponding author.

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