EMBJ.ORG FOR YOUNG DOCTORS

EuroMediterranean Biomedical Journal
2026, 21 (1)
(*Formerly: Capsula Eburnea*)

Original article

WILLINGNESS AND ADHERENCE TOWARDS SEASONAL VACCINATIONS AGAINST RESPIRATORY VIRUSES AMONG HEALTHCARE WORKERS IN A SOUTHERN ITALIAN UNIVERSITY HOSPITAL

Luigi Cirrincione,[1] Claudio Costantino,[1,2]* Santo Fruscione,[1] Ginevra Malta,[1] Maria Chiara Lo Porto,[1] Chiara Alba Norrito,[1] Giorgio Graziano,[2] Alessia Pieri,[2] Valeria Guzzetta,[2] Rita Li Muli,[2] Adriana Previti,[2] Arianna Santino,[2] Giuseppe Sferlazza,[2] Giuseppe Calamusa,[1] Ermanno Vitale,[3] Silvana Miceli,[4] Salvatore Zaffina,[5] Reparata Rosa Di Prinzio,[6] Maria Rosaria Vinci,[6] Caterina Maria Gambino,[6] Luisa Agnello,[5] Marcello Ciaccio,[5] Walter Mazzucco,[1,2] Emanuele Cannizzaro[1]*

**These authors contributed equally*

[1]Department of Health Promotion, Maternal and Child Care, Internal and Specialized Medicine of Excellence, University of Palermo; [2]Clinical Epidemiology and Cancer Registry Unit, Palermo University Hospital "Paolo Giaccone"; [3]University of Enna "Kore"; [4]Department of Psychology, Education, Exercise Science, and Training, University of Palermo; [5]Department of Biomedicine, Neuroscience, and Advanced Diagnostics, University of Palermo; [6]Occupational Medicine Unit, Bambino Gesù Children's Hospital IRCCS, Rome, Italy

ARTICLE INFO

Article history:
Received 27 January 2026
Accepted 5 May 2026
Published 7 May 2026

Keywords:
healthcare workers; seasonal vaccination; vaccine uptake; vaccine hesitancy; vaccine fatigue.

ABSTRACT

Healthcare workers (HCWs) represent a priority group for vaccination against vaccine-preventable diseases (VPDs), particularly those transmitted by airborne routes, due to both occupational exposure and their potential role in transmitting infections to vulnerable patients. Nevertheless, in many countries, including Italy, where regional disparities persist, vaccination coverage among HCWs remains suboptimal. While vaccine hesitancy is often cited as a barrier, changes in risk perception following the pandemic – and, potentially, vaccine fatigue regarding COVID-19 vaccines – could contribute to a further decline in adherence rates. The objective of this study was to assess willingness and adherence toward vaccination against respiratory viruses among HCWs at the main university hospital of Western Sicily (Italy), and to evaluate adherence to seasonal influenza and COVID-19 vaccines over two consecutive winter seasons (2023-24 and 2024-25). To this end, a cross-sectional survey was conducted among HCWs at the University Hospital of Palermo in the two seasons (n=52 and n=59, respectively). The questionnaire collected socio-demographic and professional data, vaccination uptake (influenza and COVID-19), and items from the validated Vaccine Hesitancy Scale (VHS). Trends in VHS scores and vaccination coverage were compared across seasons. Logistic regression was used to identify predictors of uptake. Participants in 2023-24 were 63% women (mean age 43.7±14.0), while in 2024-25 they were 61% women (mean age 39.0±12.9). VHS scores indicated low and stable levels of hesitancy (2023-24: 2.14±0.85; 2024-25: 2.04±0.83), with no significant differences between vaccinated and unvaccinated respondents. Nonetheless, influenza vaccine uptake declined from 59.6% (31/52) to 35.6% (21/59) (χ^2=5.27; p=0.058), and COVID-19 uptake decreased from 21.1% (11/52) to 6.8% (4/59) (χ^2=3.28; p=0.036). Despite stable and favorable attitudes, uptake of both influenza and COVID-19 vaccines among HCWs at a major referral hospital declined across the two seasons studied. This trend could reflect a phenomenon of vaccine fatigue, possibly linked to reduced salience and trust in COVID-19 vaccination, which in turn may have influenced adherence to influenza vaccination. These findings highlight the need for strategies that address not only attitudes but also organizational and contextual barriers.

* *Corresponding author:* Luigi Cirrincione, *luigi.cirrincione@unipa.it*
 ISSN: 2279-7165 - Available on-line at www.embj.org

Introduction

Vaccination is one of the most effective public health interventions ever implemented, preventing millions of deaths worldwide each year.[1] In healthcare settings, immunization of healthcare workers (HCWs) serves a dual purpose: to protect the workforce from occupational exposure and to safeguard patients, particularly those who are immunocompromised or otherwise vulnerable to serious illness. Seasonal influenza and COVID-19, while differing in epidemiology and clinical severity, both pose serious respiratory threats in healthcare settings.[2] They are associated with significant morbidity, absenteeism, and potential nosocomial outbreaks. Due to their frequent contact with patients and their role as trusted messengers, healthcare workers are critical to the success of vaccination programs.[3,4]

Despite strong recommendations from the World Health Organization (WHO), the European Centre for Disease Prevention and Control, and the Ministry of Health, flu vaccination coverage among healthcare workers in Italy remains inconsistent and often below the 75% target. Coverage for COVID-19 booster doses has declined rapidly since the emergency phase of the pandemic, with evident regional disparities: in northern Italy, coverage above 60-70% for influenza is sometimes reported, while many southern regions remain below 40%.[5] Limited data are available on the uptake of COVID-19 boosters by healthcare workers in the post-pandemic Italian context, particularly in southern facilities, where local organizational constraints and cultural factors may influence behavior.[6]

Vaccine hesitancy, defined by the WHO as "delayed acceptance or refusal of vaccines despite their availability", has often been cited as one of the main barriers to vaccination coverage. However, evidence increasingly suggests that attitudes alone are not sufficient to predict behaviors. Even HCWs who conceptually support vaccination may not act due to logistical barriers, competing work demands, or the perception that vaccination is not an immediate priority.[7] The post-pandemic landscape has further altered perceptions of risk: as the threat of COVID-19 and influenza has diminished, HCWs may have become more complacent, despite continuing to express positive views about vaccines. This raises the question of whether attitude surveys alone are sufficient to reliably capture the factors that determine actual vaccination behavior.[8]

Emerging evidence suggests that behavioral responses to health interventions are not determined solely by sociocultural and legislative factors, as in the case of the COVID-19 pandemic, where it was necessary to apply new preventive measures recommended by health authorities to contain the spread of the virus,[9,10] but they may also reflect more general mechanisms of learning, habituation, and fatigue. Experimental studies have shown that early neurobehavioral conditioning can modulate subsequent task performance and adaptive responses in animal models.[11]

Recent literature has described the phenomenon of "vaccine fatigue", understood as fatigue or inertia toward information and offers regarding vaccines after prolonged periods of intense media exposure and repeated campaigns, particularly in individuals who perform activities involving significant psychological and physical stress.[12] In the post-pandemic context, this phenomenon may have contributed to a reduction in the perceived salience and priority attributed to seasonal boosters, particularly for the COVID-19 vaccine, with possible repercussions also on adherence to the flu vaccine.

Existing studies in Italy rarely link attitude data to verified vaccination records, and even fewer have examined trends over multiple seasons after the COVID-19 pandemic.[13] Vaccine hesitancy has been described in relation to broader psychological and organizational dimensions.[14] Without this link, it is impossible to distinguish whether low coverage reflects genuine hesitancy or structural and contextual barriers. The relevance of the theme is notably known, given that seasonal flu vaccination has been linked to economic earnings under a wide public health perspective.[15]

We aimed at filling this gap of knowledge by conducting two surveys on HCWs' attitudes and willingness to be vaccinated for both influenza and COVID-19 in two consecutive cold seasons in a southern Italian university hospital. In depth, we assessed the vaccination adherence of HCWs for both vaccines, and we investigated whether attitudes and willingness were associated predictors.

Materials and Methods

Study design and context

Two independent cross-sectional surveys were conducted among a sample of HCWs employed at the University Hospital of Palermo (Italy) during two consecutive seasons with circulation of respiratory viruses (2023-24 and 2024-25). Data collection took place during the seasonal flu and COVID-19 vaccination campaigns, from December 2023 to February 2024 (first season) and from December 2024 to February 2025 (second season).

The Palermo University Hospital is an advanced tertiary setting, providing complex care with 417 beds for patients in ordinary regimes and 66 beds for patients in day-hospital regimes and several ambulatories dedicated to first diagnosis and follow-up. Overall, its healthcare workforce includes 346 physicians, 796 paramedics, and 223 administrative and support staff. Therefore, participants were consecutively selected from various hospital units, services, and departments because of their voluntary participation in the surveys. This allows us to obtain a representative sample with a confidence level of 95% and a margin of error of 10%.

Participants

All the HCWs were considered eligible for inclusion in the study, regardless of their professional category. Therefore, our study sample included physicians, medical residents, nurses, obstetricians, laboratory and radiology technicians, and other healthcare professionals. Participation was voluntary and completely anonymous.

When completing the questionnaire, each participant generated a unique alphanumeric code, which was used to establish a deterministic link with the vaccination records while ensuring the confidentiality of personal data.

Vaccination adherence against seasonal influenza and COVID-19 vaccines was checked on the vaccination registry of the Sicilian region. Those who were absent from work for the entire duration of the vaccination campaign and those who did not consent to provide the anonymous identification code required to link to the vaccination records were excluded.

Data collection and linkage

An anonymous questionnaire, previously validated on a small sample of HCWs, was self-administered during scheduled meetings in the workplaces (hospital units and services). Completing the questionnaire implied the expression of informed consent by the participants. The questionnaire was divided into three sections: i) socio-demographic and professional characteristics (age, gender, role, hospital unit, and years of service; ii) previous vaccination history and future intentions to participate in seasonal campaigns; and iii) attitudes toward vaccination.

The section on attitudes included ten items adapted from the Vaccine Hesitancy Scale (VHS) previously validated[16] aimed at exploring the perceived importance and effectiveness of vaccinations, trust in health authorities, concerns about potential adverse events, and willingness to comply with institutional recommendations. Responses were expressed on a 5-point Likert scale, from *not at all hesitant* (1) to *very hesitant* (5). An overall average vaccine hesitancy score was then calculated, with higher values indicating greater hesitancy. The vaccination repository systematically documented all vaccinations administered to HCWs during the different seasonal campaigns, including both flu vaccine boosters and COVID-19 vaccines. Each participant was associated through an anonymous alphanumeric identification code with the questionnaire, which allowed the data reported to be uniquely traced back to the corresponding vaccination records, while ensuring full confidentiality. Based on this information, two binary variables (vaccinated/unvaccinated) were created for influenza vaccination and COVID-19 vaccination. Only participants for whom it was possible to correctly associate the questionnaires with the vaccination records were included in the adherence analyses. Questionnaires that were incomplete (less than 50% of items completed) were excluded from the analysis (n=2 and n=1, respectively).

Adherence against influenza and COVID-19 was evaluated by accessing the Regional Vaccination Registry, operating since May 2024. Data on vaccination adherence during the first season of analysis (2023-24) were retrospectively registered during May and June 2024.

Statistical analysis

The main outcomes considered in the study were the administration of the flu vaccine and the COVID-19 vaccine (dichotomous variables: yes/no). The independent variables included age, gender, professional category, year of data collection, and the average score relating to attitude towards vaccination.

The characteristics of the sample were described using means and standard deviations for continuous variables and proportions for categorical variables. Differences in vaccination adherence among study participants between the two years were assessed using Pearson's chi-square test, while differences in mean attitude scores between vaccinated and unvaccinated subjects were examined

using Welch's *t*-test. To analyze the factors associated with the likelihood of vaccine adherence, multivariate logistic regression models were estimated, from which odds ratios (OR) and their 95% confidence intervals (CIs) were derived, calculated from the regression coefficients (OR=e^β). All statistical analyses were performed using R software. A two-tailed significance level of a p-value of 0.05 was adopted. To further explore whether vaccination uptake was influenced by temporal factors, independently of individual attitudes, we estimated two separate multivariate logistic regression models, one for influenza vaccination and one for COVID-19 vaccination. In these vaccine-specific models, the dependent variable was the receipt of the corresponding vaccine (yes/no). The main independent variables of interest were the year of survey (2024-25 *vs.* 2023-24), considered as a proxy for temporal and contextual factors, and the VHS, entered as a continuous covariate to account for individual attitudes toward vaccination. ORs and 95% CIs were derived from the regression coefficients. These models were designed to disentangle the relative contribution of temporal dynamics and vaccine hesitancy to influenza and COVID-19 vaccination behaviors. The study was conducted in compliance with current regulations and institutional and regional ethical guidelines, in accordance with the principles of the Declaration of Helsinki. All data collected were anonymized before analysis and processed exclusively in aggregate form; no personally identifiable information was acquired. The study protocol was approved by the Ethics Committee of the University Hospital of Palermo (10/2022, released on November 16, 2022). Participation was voluntary, and completion of the questionnaire implied the participants' informed consent.

Results

Overall, 111 completed questionnaires were collected from HCWs of the Palermo University Hospital, of which 52 (46.8%) referred to the 2023-24 and 59 (53.2%) to the 2024-25 vaccination campaigns, respectively.

Among the participants in the first campaign, 33 (63%) were females and 19 (37%) were males, with a mean age of 41.4 years (standard deviation [SD]±14.8), while in the second campaign, 36 (61%) were women and 28 (39%) were men, with a mean age of 36.4 years (SD±15.2). The average vaccine hesitancy score, calculated on a Likert scale from 1 (*no hesitancy*) to 5 (*maximum hesitancy*), was 2.14 (SD±0.85) in 2023-24 and 2.04 (SD±0.83) in 2024-25 (Table 1). A more detailed analysis by single item is presented in Table 2, which shows the mean values and SDs for each statement across the two surveyed seasons. The results highlight substantial consistency between 2023-24 and 2024-25, with only minimal variations that were not statistically significant. Precisely, the average VHS score remained low and stable in both seasons (2.14 in 2023-24 and 2.13 in 2024-25 on a scale of 1-5), with no significant differences between the two seasons or between vaccinated and unvaccinated individuals. Among the participants for whom it was possible to uniquely associate the data with vaccination records, 31 out of 52 (59.6%) received the flu vaccine in the 2023-24 season, compared to 21 out of 59 (35.6%) in the 2024-25 season. This difference represents a decline, although not statistically significant, in flu vaccination adherence between the two seasons among the HCWs involved in the study (χ^2=5.27; p=0.058). Otherwise, coverage of COVID-19 seasonal booster vaccination showed a significant reduction between the two seasons considered. In the 2023-24 season, among participants HCWs, 11 out of 52 (21.1%) had received a COVID-19 booster, while in the 2024-25 season, only 4 out of 59 (9.1%; χ^2=3.28; p=0.04) were vaccinated against COVID-19 (Table 3). In the

Table 1. Socio-demographic characteristics of the study sample and average vaccine hesitancy scores obtained in the questionnaire on attitudes toward vaccinations.

Season	Gender	n	Average age (years)	SD	n	Average score (1-5)	SD
2023-24	Female	33	43.7	14.0	52	2.14	0.85
	Male	19	37.8	15.8			
2024-25	Female	36	39.0	12.9	59	2.04	0.83
	Male	28	39.0	16.3			

Table 2. Comparisons of attitudes toward vaccinations by single items of the VHS (2023-24 *vs.* 2024-25).

Items	2023-24 (Mean±SD)	2024-25 (Mean±SD)
Vaccines are effective	1.67±1.04	1.62±1.02
Being vaccinated is important for the health of others in my community	1.67±1.06	1.64±1.10
All routine vaccinations recommended by the Ministry are useful	1.58±1.05	1.66±1.07
New vaccines carry more risks than older vaccines	1.60±0.98	1.71±1.06
The information I receive about vaccines from the CDC is reliable	2.42±1.29	2.47±1.25
Access to vaccines is a good way to protect myself from diseases	1.86±1.04	1.91±1.03
I generally follow my physician's advice regarding vaccinations	1.77±1.12	1.82±1.08
I am worried about serious adverse effects of vaccines	2.21±1.27	2.34±1.21
I do not need vaccines for diseases that are no longer common	1.74±1.05	1.80±1.02
In general, I trust the national vaccination program	1.69±1.01	1.72±1.00
Average VHS score	2.14±0.85	2.13±0.74

CDC, Centers for Disease Control and Prevention; VHS, Vaccine Hesitancy Scale.

Table 3. Comparison of adherence rate to seasonal influenza and COVID-19 vaccination among HCWs (2023-24 *vs.* 2024-25).

Cold season	Study sample (n)	Seasonal influenza vaccination (n)	Vaccinated (%)	χ^2	p	Seasonal COVID-19 vaccination	Vaccinated (%)	χ^2	p
2023-24	52	31	59.6	5.27	0.06	11	21.1	3.28	0.04
2024-25	59	21	35.6			4	6.8		

aggregate analyses (two seasons combined), participants who had received the flu vaccine had an average hesitancy score of 2.15 (SD±0.91), compared to 2.02 (SD±0.75) among those who were not vaccinated (Welch's t= 0.70; p=0.49). Similar results were observed for COVID-19 vaccination. Stratified analyses by year did not reveal any consistent differences (p=>0.05), suggesting that individual attitudes were not a significant determinant of vaccination behavior (Table 4).

To better explore the factors potentially associated with the overall vaccine uptake, we first performed a multivariate logistic regression model including age, gender, occupational category, and year of survey as covariates (Table 5). The age was not significantly associated with the probability of being vaccinated (OR=1.00; 95% CI: 0.96-1.03; p=0.77), indicating the absence of a meaningful linear trend between increasing age and the likelihood of vaccine uptake. Similarly, gender did not emerge as a predictor: female participants had lower odds than males (OR=0.71; 95% CI: 0.29-1.77; p=0.47), but the wide confidence interval overlapped the null value.

Regarding the occupational category, we grouped respondents into clinical *vs.* non-clinical roles to improve model stability. Even in this case, no statistically significant differences emerged (OR=0.52; 95% CI: 0.09-2.96; p=0.47). The results of the vaccine-specific multivariate logistic regression models are reported in Table 5. For influenza vaccination, the year of survey emerged as the only significant predictor of uptake: participation in the 2024-25 season was associated with a substantially lower likelihood of influenza vaccination compared to the 2023-24 season (OR=0.18; 95% CI: 0.06-0.52; p=0.001). In contrast, the VHS was not significantly associated with influenza vaccination (OR=1.11 per point increase; 95% CI: 0.59-2.11; p=0.74).

Similarly, in the model for COVID-19 vaccination, the year of the survey was significantly associated with vaccine uptake, with the HCWs surveyed in 2024-25 showing markedly lower odds of receiving a COVID-19 booster compared to those surveyed in 2023-24 (OR=0.25; 95% CI: 0.07-0.87; p=0.03). No significant association was observed between the VHS and COVID-19 vaccination (OR=0.66; 95% CI: 0.31-1.43; p=0.29).

Discussion

This study investigated willingness and adherence to seasonal vaccinations against respiratory viruses among HCWs in a southern Italian university hospital, highlighting behavioral patterns, determinants of vaccine uptake, and persistent barriers to immunization.

We highlighted a marked decline in vaccination uptake for both influenza and COVID-19 among HCWs from a southern Italian university hospital during two consecutive vaccination seasons, despite generally stable and favorable attitudes toward vaccination. In particular, adherence to the flu vaccine decreased by 24%, while adherence to the COVID-19 booster fell by two-thirds.

The results obtained are consistent with numerous findings from European and national studies, which have documented a decline in vaccine uptake among healthcare workers in the post-pandemic phase, despite generally positive attitudes.[3,5,14,17] This apparent discrepancy suggests that the main barriers are not cognitive or value-based, but mainly organizational and logistical.

The adopted study design allowed us to test the hypothesis that positive attitudes are necessary but not sufficient for increasing vaccination uptake among HCWs.

A clear misalignment between attitudes and vaccination behaviors suggests that the mere presence of positive opinions is not sufficient to guarantee high levels of adherence and that organizational and contextual factors have likely played a decisive role in the observed decline.

Without the extraordinary campaigns involving high-intensity communication and simplified access that were activated during the pandemic emergency, many HCWs may have encountered greater practical difficulties in accessing vaccination services, especially in departments with high workloads or irregular shifts.[18] Studies conducted in Italy and France have shown that the implementation of targeted logistical strategies (*e.g.*, vaccination in wards, flexible hours, mobile units) leads to a substantial increase in coverage, greater than that achieved through information-only interventions.[6,19,20]

Even individuals with favorable attitudes toward vaccination may not adhere to the schedule if vaccination sessions are planned inflexibly, reminder systems are weak, or vaccination is perceived as non-urgent.[7]

To translate these findings into concrete implications for the healthcare context, it is useful to distinguish between different categories of organizational, behavioral, and institutional interventions that can be implemented at the hospital level.

First, organizational strategies should aim to reduce structural barriers to vaccination access. These include on-site vaccination programs on wards, mobile vaccination teams, flexible or extended scheduling (including night shifts), and the implementation of automated reminder and recall systems integrated into hospital information systems. These measures directly address time constraints and accessibility issues, which appear to be the main determinants of missed vaccination opportunities.

Second, behavioral interventions can be leveraged to influence decision-making processes even in the presence of favorable attitudes. Approaches derived from behavioral sciences, such as vaccination appointments with a default opt-out option, digital prompts, comparative peer feedback, and the use of clinical reference figures within wards, are among the most effective. Such

Table 4. Aggregated analysis (two seasons combined) of attitudes and behaviors on vaccinations, assessed with VHS, measured on a 1-5 scale (1 = no hesitancy, 5 = strong hesitancy).

Type of vaccine	Vaccination status	n	Average score (1-5)	SD	t	p
Influenza	Vaccinated	52	2.15	0.91	0.70	0.49
	Unvaccinated	49	2.02	0.75		
COVID-19	Vaccinated	15	2.12	≈0.9	n.s.	>0.05
	Unvaccinated	96	2.7	≈0.8		

n.s., not significant.

Table 5. Multivariable logistic regression analysis estimating predictors of influenza and COVID-19 vaccination uptake.

Predictor	OR	95% CI	p
Influenza vaccination			
2024-25 *vs.* 2023-24	0.18	0.06-0.52	0.001
VHS (per point increase)	1.11	0.59-2.11	0.74
COVID-19 vaccination			
2024-25 *vs.* 2023-24	0.25	0.07-0.87	0.03
VHS (per point increase)	0.66	0.31-1.43	0.29

OR, odds ratio; CI, confidence interval; VHS, Vaccine Hesitancy Scale.

measures can increase adherence by making vaccination the easier or more socially acceptable choice. These interventions could be particularly relevant in contexts characterized by vaccine fatigue, where inertia rather than resistance prevails.

Finally, the third level of concrete interventions should involve institutional and policy measures to maintain high vaccination coverage over time. These may include formal hospital policies promoting vaccination, linking vaccination status to occupational health requirements, introducing incentives (*e.g.*, recognition programs or professional benefits), or, where appropriate and ethically justified, mandatory vaccination policies for high-risk settings. Experience suggests that such measures can substantially increase adherence when combined with accessible delivery systems.

In the post-COVID-19 pandemic context, a certain degree of complacency may have set in, fuelled by a lower perception of the risk and severity of the disease. At the same time, healthcare facilities may have reduced the intensity and visibility of vaccination campaigns, offering fewer on-site sessions and adopting less effective promotional strategies than in the years immediately following the pandemic.[21]

The particularly sharp decline in COVID-19 booster shots highlights how quickly vaccination coverage can decline when institutional and organizational pressure is removed. During the pandemic, COVID-19 vaccination of healthcare workers was strongly promoted, in some contexts made mandatory, and closely integrated into the operational flows of healthcare facilities, leading to high levels of uptake.

In 2024, with the gradual easing of the sense of urgency and the reduction of organizational incentives, uptake rates plummeted, confirming that a solid organizational infrastructure and the ongoing commitment of health leaders are essential to sustaining high vaccination coverage levels over time.

Overall, our findings suggest that effective vaccination strategies in hospital settings should adopt a multilevel approach, combining organizational facilitation, behavioral knowledge, and institutional commitment. Isolated interventions are unlikely to be sufficient, while integrated strategies can significantly improve the translational impact of vaccination programs.

The results of this study suggest that vaccine hesitancy measures may have limited predictive power in post-pandemic contexts characterized by generally favorable attitudes. Although useful for identifying highly resistant subgroups, traditional hesitancy scales may fail to capture practical and organizational barriers, which can become predominant when basic trust in vaccines is high.

HCWs, despite being more frequently exposed to patients and potentially more sensitive to health promotion policies, did not show significantly higher odds of vaccination compared with non-clinical staff. This result should be interpreted with caution, as the limited sample size and the heterogeneity of the non-clinical group may have reduced the power to detect small but real differences.

Participation in the 2024-25 survey tended to be linked to lower odds of vaccine uptake compared with the 2023-24 season, but the wide confidence interval suggests limited precision of this estimate.

Overall, despite the limits of the available sample, these findings suggest that vaccine uptake was relatively homogeneous across age groups, genders, and occupational categories, whereas temporal dynamics between survey years exerted the only measurable influence on vaccination behaviors, although not always statistically significant.

This interpretation is in line with experimental evidence showing that early neurobehavioral conditioning and pharmacological exposures may influence stress reactivity and adaptive responses later in life (*e.g.*, prenatal exposure to diazepam and alprazolam affecting stress reactivity in rat progeny).[22] Although in a different context, such findings support the view that fatigue, habituation, and behavioral inertia can substantially modulate responses to repeated stimuli, including public health interventions such as seasonal vaccination campaigns.

The substantial decline in vaccination uptake observed between the 2023-24 and 2024-25 seasons, in the absence of a concomitant rise in hesitancy scores, indicates that the reduction was unlikely to be attributable to individual attitudes alone. Rather, it points to the influence of temporal and contextual determinants. This dynamic aligns with the notion of "vaccine fatigue", which has been described in the post-pandemic literature as a state of psychological and behavioral inertia towards repeated vaccination offers after a period of intense immunization campaigns and continuous public health messaging.[8] In our cohort, VHS values remained consistently low, suggesting that healthcare workers preserved a generally favorable orientation toward vaccination. Nevertheless, their actual uptake diminished significantly. This discrepancy underscores the role of fatigue, declining perceptions of urgency, and organizational contingencies – such as less structured campaigns, reduced availability of on-site sessions, and scheduling difficulties – in shaping vaccine behavior. Comparable patterns have been documented across Europe, where participation in COVID-19 booster campaigns has progressively decreased among healthcare professionals as well as in the general population.[13,23] Within this interpretative framework, it is plausible that the waning salience of COVID-19 vaccination contributed indirectly to the reduced adherence to influenza vaccination, reinforcing the hypothesis of a spillover effect of vaccine fatigue across different seasonal immunization programs.

One of the main strengths of this study is the integration of self-reported attitude data with verified company vaccination records, which reduced the risk of self-assessment bias and provided a more accurate estimate of actual behaviors. Furthermore, the two consecutive surveys allowed for an analysis of the evolution of vaccine uptake over time, providing insights into its trend in a post-pandemic context.

The joint inclusion of influenza and COVID-19 vaccinations is a further strength, as it offers a broader and more comparative view of vaccination behaviors among healthcare workers.

This study has some methodological limitations that must be considered when interpreting the results. First, the relatively small sample size limited statistical power, reducing the ability to identify modest associations between variables. Furthermore, not all questionnaire participants were correctly matched to vaccination records, which may have introduced a potential selection bias, as subjects with unmatched data may have systematically different characteristics. In addition, the voluntary nature of participation may have further contributed to selection bias, as HCWs more interested in vaccination topics or more engaged with institutional initiatives may have been more likely to participate, potentially limiting the representativeness of the sample. The combination of voluntary enrollment and incomplete linkage with vaccination registries may, therefore, have led to an over- or underestimation of true vaccination behaviors.

A further critical issue concerns the measurement of vaccination attitudes, based on a general hesitancy scale: although validated, this measure may not adequately capture the behavioral and organizational factors specific to the context, which appear to have a decisive influence in our study. More specifically, the VHS may not fully reflect context-specific dimensions such as vaccine fatigue, perceived inconvenience, or logistical barriers to access, potentially resulting in a misclassification of attitudes and an underestimation of their complexity in real-world healthcare settings.

Another important limitation relates to the potential presence of residual confounding. Although multivariate models included key sociodemographic and professional variables, other relevant determinants such as workload intensity, staffing shortages, actual accessibility of vaccination services, and the organizational culture of individual departments were not directly measured and could have influenced vaccination behaviors. Moreover, the cross-sectional design of the study inherently limits the ability to draw causal inferences. The use of two independent samples across consecutive seasons does not allow for a longitudinal assessment at the individual level, preventing the evaluation of how attitudes and behaviors evolve over time within the same HCWs.

Finally, the survey was conducted in a single university hospital center located in southern Italy, which limits the generalizability of the results to other geographical and organizational contexts with different structural or cultural characteristics.

Conclusions

This study highlights that, among the sample of HCWs from a southern Italian university hospital setting, attitudes toward vaccination remained positive, with low levels of hesitancy across two consecutive seasons. Despite this stability in attitudes, uptake of both influenza and COVID-19 vaccines declined markedly. Such divergence suggests that the reduction in coverage was not primarily driven by individual reluctance, but rather by contextual and organizational dynamics. In particular, the findings are compatible with a phenomenon of vaccine fatigue, whereby reduced salience and trust in COVID-19 vaccination may have indirectly affected adherence to influenza vaccination.

To sustain high vaccination uptake among HCWs over time against respiratory viruses, interventions should therefore extend beyond persuasive communication and actively address structural barriers.

From a practical perspective, hospital-based strategies should be clearly structured across three complementary domains: i) organizational interventions, such as on-site vaccination delivery, flexible access, and digital reminder systems; ii) behavioral approaches, including nudging strategies, default vaccination appointments, and peer influence mechanisms; and iii) institutional measures, such as formal policies, incentive schemes, and, where appropriate, mandatory requirements for high-risk settings.

Adopting this integrated framework may enhance the effectiveness and

sustainability of vaccination campaigns, providing concrete guidance for healthcare managers and policymakers aiming to improve coverage among HCWs. Given that the two samples analyzed were independent and not directly comparable, these results should be interpreted with caution. Nonetheless, they underscore the importance of recognizing and counteracting vaccine fatigue to preserve long-term adherence to seasonal vaccination programs in healthcare settings against respiratory diseases.

Conflict of interest: the authors have no conflict of interest to declare.

Ethics approval and consent to participate: the study protocol was approved by the Ethics Committee of the University Hospital of Palermo (10/2022, released on November 16, 2022). Participation was voluntary, and completion of the questionnaire implied the participants' informed consent.

Availability of data and materials: the datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

1. Arzilli G, Stacchini L, Casigliani V, et al. Assessing vaccine hesitancy and health literacy using a new Italian vaccine confidence index and a modified Italian medical term recognition test: A cross-sectional survey on Italian parents. Hum Vaccin Immunother 2023;19:2271765.
2. Costantino C, Casuccio A, Caracci F, et al. Impact of Communicative and Informative Strategies on Influenza Vaccination Adherence and Absenteeism from Work of Health Care Professionals Working at the University Hospital of Palermo, Italy: A Quasi-Experimental Field Trial on Twelve Influenza Seasons. Vaccines 2019;8:5.
3. Gur-Arie R. Maximizing influenza vaccination uptake among healthcare personnel in Israel: lessons learned from mandatory vaccination policy in the United States. Isr J Health Policy Res 2019;8:60.
4. Costantino C, Amodio E, Calamusa G, et al. Could university training and a proactive attitude of coworkers be associated with influenza vaccination compliance? A multicentre survey among Italian medical residents. BMC Med Educ 2016;16:38.
5. Hajure M, Tariku M, Bekele F, et al. Attitude Towards COVID-19 Vaccination Among Healthcare Workers: A Systematic Review. Infect Drug Resist 2021;14:3883-97.
6. Maltezou HC, Dounias G, Rapisarda V, Ledda C. Vaccination policies for healthcare personnel: Current challenges and future perspectives. Vaccine X 2022;11:100172.
7. Della Polla G, Miraglia Del Giudice G, et al; Collaborative Working Group. Willingness to accept a second COVID-19 vaccination booster dose among healthcare workers in Italy. Front Public Health 2022;10:1051035.
8. SteelFisher GK, Findling MG, Caporello HL, et al. Divergent Attitudes Toward COVID-19 Vaccine vs Influenza Vaccine. JAMA Netw Open 2023;6:e2349881.
9. Cirrincione L, Rapisarda V, Mazzucco W, et al. SARS-CoV-2 and the Risk Assessment Document in Italian Work; Specific or Generic Risk Even If Aggravated? Int J Environ Res Public Health 2021;18:3729.
10. Costantino C, Cannizzaro E, Verso MG, et al. SARS-CoV-2 Infection in Healthcare Professionals and General Population During "First Wave" of COVID-19 Pandemic: A Cross-Sectional Study Conducted in Sicily, Italy. Front Public Health 2021;9:644008.
11. Cannizzaro C, Plescia F, Gagliano M, et al. Effects of pre- and postnatal exposure to 5-methoxytryptamine and early handling on an object-place association learning task in adolescent rat offspring. Neurosci Res 2007;59:74-80.
12. Cannizzaro E, Plescia F, Cirrincione L, et al. Sport for job. Differences in cortisol levels in a water polo team at different times of training. Euromediterranean Biomed J 2018;13.
13. Vallis M, Bacon S, Corace K, et al. Ending the Pandemic: How Behavioural Science Can Help Optimize Global COVID-19 Vaccine Uptake. Vaccines 2021;10:7.
14. Di Prinzio RR, Ceresi B, Arnesano G, et al. The impact of vaccine hesitancy on psychological impairment among healthcare workers in a Total Worker Health© approach. Front Public Health 2024;12:1447334.
15. Zaffina S, Gilardi F, Rizzo C, et al. Seasonal influenza vaccination and absenteeism in health-care workers in two subsequent influenza seasons (2016/17 and 2017/18) in an Italian pediatric hospital. Expert Rev Vaccines 2019;18:411-8.
16. Ledda C, Costantino C, Liberti G, Rapisarda V. The Italian Version of the Adult Vaccine Hesitancy Scale (aVHS) for the Working-Age Population: Cross-Cultural Adaptation, Reliability, and Validity. Vaccines 2022;10:224.
17. Kafadar AH, Sabatini S, Jones KA, Dening T. Categorising interventions to enhance vaccine uptake or reduce vaccine hesitancy in the United Kingdom: A systematic review and meta-analysis. Vaccine 2024;42:126092.
18. Kłoda K, Mierzecki A, Mastalerz□Migas A, Babicki M. Beneficial effects of SARS-CoV-2 vaccination resulting from the COVID-19 pandemic with regard to the uptake of influenza virus, pneumococcal, and herpes zoster adult vaccination – a narrative literature review. Ann Agric Environ Med 2023;30:587-94.
19. Lymon H, Meng L, Reses HE, et al. Declines in Influenza Vaccination Coverage Among Health Care Personnel in Acute Care Hospitals During the COVID-19 Pandemic — United States, 2017–2023. MMWR Morb Mortal Wkly Rep 2023;72:1244-7.
20. Peterson CJ, Lee B, Nugent K. COVID-19 Vaccination Hesitancy among Healthcare Workers - A Review. Vaccines 2022;10:948.
21. Rapisarda V, Cannizzaro E, Barchitta M, et al. A Combined Multidisciplinary Intervention for Health Promotion in the Workplace: A Pilot Study. J Clin Med 2021;10:1512.
22. Cannizzaro C, Martire M, Steardo L, et al. Prenatal exposure to diazepam and alprazolam, but not to zolpidem, affects behavioural stress reactivity in handling-naïve and handling-habituated adult male rat progeny. Brain Res 2002;953:170-80.
23. Walkowiak MP, Domaradzki J, Walkowiak D. Are We Facing a Tsunami of Vaccine Hesitancy or Outdated Pandemic Policy in Times of Omicron? Analyzing Changes of COVID-19 Vaccination Trends in Poland. Vaccines 2023;11:1065.