COVID-19

Knowledge and training of Italian students in Healthcare Settings on COVID-19 vaccines and vaccination strategies, one year after the immunization campaign

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Keywords

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Summary

Introduction. *COVID-19 vaccines represent an important opportunity for defeating the disease, as long as high vaccination acceptance rates are achieved. Healthcare workers (HCWs) have a relevant role in the promotion of immunization among the population and since students in healthcare area will be HCWs it is crucial to provide more in-depth knowledge on vaccinations. Therefore, the aim of the study is to assess the knowledge of medical and pharmaceutical area students regarding COVID-19 vaccination and the impact of a specific Elective Teaching Activity (ETA) on the increase of students' knowledge. The ETA was held one year after the immunization campaign in Italy.*
Methods. *Students' knowledge was tested with a questionnaire before and after attending the course. Descriptive statistical methods were used to analyse the results obtained. Student's t-tests for paired data were used.*
Results. *Overall, 387 students at the University of Florence attended the course and took the same test before and after the ETA on COVID-19 vaccines. Despite achieving satisfactory average scores in the pre-course test (26/32 ± 4.0), all students were able to significantly enhance their final score (+17.1%; $p < 0.001$), indicating that the ETA was highly effective in improving their knowledge of COVID-19 vaccination. Medical students demonstrated a better comprehension of the role of the medical specialist in public health in the COVID-19 vaccination campaign, while some uncertainties were revealed regarding the role of pharmacists.*
Conclusions. *The results of this study confirm that specific training activities on vaccination are effective for implementing the knowledge of future health professionals.*

Introduction

Vaccinating against COVID-19 represents an important opportunity to mitigate the pandemic's spread, decrease hospitalizations and ease the burden on the healthcare system [1]. The World Health Organization (WHO) considers that all people should have access to safe and effective COVID-19 vaccines as quickly as possible, starting with those at high risk of severe disease or death [2].
Implementing global and national vaccination programs, combined with non-pharmaceutical interventions, are useful tools to reduce the spread of the COVID-19 pandemic [3]. The COVID-19 vaccination campaign started on 27 December 2020 in Italy and in Europe with the launch of Vaccination Day (effective on 31 December 2020) [4].
Currently, most countries, including Italy, are continuing to administer booster doses of COVID-19 vaccines. In May 2023, 49,598,386 people have completed the primary vaccination cycle (more than 80% of the entire population) while 40,633,693 have completed the booster dose in Italy [5]. Nevertheless, there is a growing concern that vaccine hesitancy towards COVID-19 vaccination may impede the worldwide achievement of benefits derived from preventive activities in different regions [6].
The term "Vaccine Hesitancy" has been defined as the act of delaying acceptance or refusing vaccination despite the availability of vaccination services [7] and, in 2019, the WHO included vaccine hesitancy as one of the ten threats to global health of the year [8]. Given cases of fatal adverse reactions following vaccination, the scientific community must work diligently to combat vaccine hesitancy regarding COVID-19 among the general public. The success of a worldwide vaccination campaign represents a significant challenge for the scientific community in the battle against COVID-19, and thus, it is crucial to furnish scientific evidence to mitigate any doubts held by the public [9]. Additionally, it is important to note that a recent analysis of social media revealed a substantial amount of misinformation related to COVID-19 vaccines [10].

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Gaining insights into the factors that can affect the willingness to refuse COVID-19 vaccination could help in developing future public health strategies designed to boost vaccination rates [11, 12].
Starting in 2020, the Italian government has launched several campaigns and messages to encourage people to get vaccinated, including television, radio, and social media advertisements. These campaigns also addressed common vaccine myths and misconceptions [13-14].
Considering what has been stated before, an appropriate knowledge of vaccinations among healthcare workers can significantly influence vaccine acceptance among their relatives, patients and, lastly, the general population as they are considered competent persons and reliable sources of information [15]. Hence, it is important to place emphasis on the education of healthcare students who will have direct contact with patients and should follow the same guidelines as healthcare professionals [16].
Therefore, the primary objective of the study was to evaluate the knowledge of medical and pharmaceutical area students regarding COVID-19 vaccines and vaccination strategies, and the impact of a specific Elective Teaching Activity (ETA) on the increase of student's knowledge on related topics, after the release of many types of COVID-19 vaccines and a booster vaccination campaign in Italy.

Materials and methods

The elective teaching activity

An optional ETA was held at the University of Florence (Italy) on COVID-19 vaccines and vaccination strategies. The course was attended by students from the Medicine and Surgery degree courses, as well as from the pharmaceutical area. The lessons took place at the beginning of 2022 (January and February 2022) through the Webex online platform using Moodle (Modular Object-Oriented Dynamic Learning Environment), a learning management system (LMS). Moodle is an open-source platform that enables the storage and retrieval of educational materials, the creation of questionnaires and tasks, the provision of exercise support, the attendance of online lessons, and the use of collaborative work tools.
The ETA (8 hours) included lessons on different types of vaccines developed through traditional methods and the new technologies used for COVID-19 vaccines. The purpose of this course was to make students aware of the benefits of anti-COVID-19 mass vaccination implementation based on scientific evidence. Therefore, the ETA aimed at making students acquire knowledge on the efficacy and safety of COVID-19 vaccines, by examining in depth the topic of vaccine vigilance. After the ETA, the role in the Italian COVID-19 vaccination plan of both the medical specialist in public health and the pharmacist was described to the students.

Test

To assess the impact of the ETA available on the Moodle platform, each participant was required to complete a designated test, with the same questions, before and after attending the ETA. Although participation in the course was voluntary, only individuals who completed the ETA were eligible to take the post-lecture test. The test comprised 12 multiple-choice questions on the subjects covered in the teaching activity (supplemental file). The first nine questions were the same for students of both Medical and Pharmaceutical degrees: questions 1 to 3 focused on clinical COVID-19 vaccine development, questions 4 to 6 on the national COVID-19 vaccination plan and the categories of the population to be vaccinated, and finally questions 7 to 9 addressed the issue of adverse events following immunization (AEFI) and vaccine vigilance. Questions 10 to 12 differed according to the degree course. In detail, questions 10-12 for medical students focused respectively on the role of the medical specialist in public health. On the other hand, questions 10-12 for students of the pharmaceutical area focused on the pharmacist's role in the implementation of the COVID-19 vaccination plan in Italy. The choice of inserting a few specific questions (but the same in the pre-course and post-course tests) for each degree program was aimed at assessing the student's knowledge of the role of medical specialist in public health and pharmacist in COVID-19 vaccination respectively. A score was assigned to each correct answer, for a total of 32 points (the passing grade was 18 points). A comparison between pre- and post-course test scores was performed. In addition, the change in the number of incorrect/correct answers in the pre-and post-course test was analysed for each question.
After being given a brief explanation of the survey's objective, students consented to participate in the tests by selecting the "I agree" option in the informed consent provided along with the test. The questionnaire, which was conducted online, did not require any specific health information. The only information requested was university ID number, gender, and degree course. This information was already publicly available, therefore there was no need to seek ethical approval to conduct the study.
All data were collected and managed in an aggregated format in accordance with the European Union Regulation 2016/679 and the Italian Legislative Decree 2018/101.

Statistical analysis

The results obtained before and after attending the course were analysed using descriptive statistical methods. Categorical data were expressed as numbers and percentages and then compared using the Chi-square test, while continuous data were presented as mean and standard deviation (SD) and compared using the Student's t-test.
The paired Student's t-test was used to compare the total scores obtained before and after attending the ETA. A p-value of 0.05 was considered statistically significant. SPSS was used to analyse all the data (IBM SPSS Statistics 28.0.0.0).

Results

The students who took the test before the course were 411. In detail, 387 attended the ETA and have taken both the pre and post-course tests. Of these, 297 (76.7%) were enrolled in Medicine, 59 (15.2%) in Pharmacy, 28 (7.2%) in Applied Pharmaceutical Sciences- Quality Control (SFA-CQ) and 3 (0.8%) in Chemistry and Pharmaceutical Technologies (CTF).

For convenience, we have merged students from Pharmacy, SFA-CQ and CTF into one category called "pharmaceutical area" (n=90; 23.3%). Most students were females (n = 251; 64.9%) (Tab. I), attending the IV year of study (n = 106; 27.4%).

The students from the pharmaceutical area achieved an average total score of 23/32 on the pre-course test and a score of 28/32 on the post-course test (+19.2%; $p < 0.001$). On the other hand, medical students obtained an average total score of 27/32 on the pre-course test and a score of 31/32 on the post-course test (+16.5%; $p < 0.001$). The T-student tests for paired data demonstrated a statistically significant improvement in all student groups. Regardless of their degree, students demonstrated an increase in their knowledge after attending the ETA (+17.1%; $p < 0.001$) (Tab. II).

We observed a slight difference between males and females in the percentage increase of the average pre/post course test scores in the overall student population: the test score showed a variation of +17.5% (from 25.2 to 29.6) for males, while a slightly higher variation of +18% (from 25 to 29.5) was observed in females. In addition, among medical students, females improved their knowledge slightly more than males, while among pharmaceutical area students, males reached fairly higher improvement than females (Tab. III).

Subsequently, the answers were analysed by specific topics. Table IV shows the distribution of correct answers for each question. The topic with the highest percentage of correct answers was the one on the COVID-19 vaccination plan. Independently from the degree academic course, a general trend towards increasing percentages of correct answers given in post-course tests was observed (Fig. 1).

The questions for which we observed a greater reduction in the total number of incorrect answers in the post-course test were: "Question 1 - The current COVID-19 vaccines authorized by AIFA in Italy are:" (from 52.4% to 15.5%), "Q2 - Janssen vaccine contains:" (from 32.8% to 3.9%), "Question 9 - The most AEFI for the COVID-19 vaccine concerned the administration of:" (from 67.9% to 16.6%). Another question for which a reduction in wrong answers has been observed was "Question 6 - The extension of compulsory COVID-19 vaccination currently concerns:" and in particular the decrease in incorrect answers was highlighted for the option "People over 12 years of age" (from 9 % to 1.6%). As regards other questions, incorrect answers were few and without any relevant differences between pre- and post-course tests. Furthermore, questions 10 to 12 focused on the role of the public health specialist

Tab. I. Students' characteristics (*n*=387 students).

Faculty	Gender		Year of study				
	Females n (% in Row)	Males n (% in Row)	II n (% in Row)	III n (% in Row)	IV n (% in Row)	V n (% in Row)	VI n (% in Row)
Medicine n = 297	176 (59.3)	121 (40.7)	-	-	106 (35.7)	96 (32.3)	95 (32)
Pharmaceutical area n = 90	75 (83.3)	15 (16.7)	9 (10)	29 (32.2)	6 (6.7)	46 (51.1)	-
Overall	251 (64.9)	136 (35.1)	9 (2.3)	29 (7.5)	112 (29)	142 (36.7)	95 (24.5)

Tab. II. Students' scores (mean± SD) in pre- and post-course tests.

Faculty	Pre-course	Post-course	p-value*	Δ%
Medicine	27.6 ± 3.2	31.4 ± 1.6	< 0.001*	+16.45%
Pharmaceutical area	23.1 ± 4.4	27.6 ± 3.2	< 0.001*	+19.23%
Overall	26 ± 4.0	30.5 ± 2.6	< 0.001*	+17.05%

* t-student test for paired data.

Tab. III. Average total tests scores (mean±SD), in males and females.

Faculty	Average pre-course test score	p-value*	Average post-course test score	p-value*	p-value pre-/post-course*
Medicine					
Males	27 ± 4	0.5	31.3 ± 1.7	0.3	p < 0.001
Females	26.9 ± 3.1		31.4 ± 1.5		p < 0.001
Pharmaceutical area					
Males	23.3 ± 3.8	0.09	27.9 ± 3.2	0.7	p < 0.001
Females	23.1 ± 4.5		27.5 ± 3.3		p < 0.001

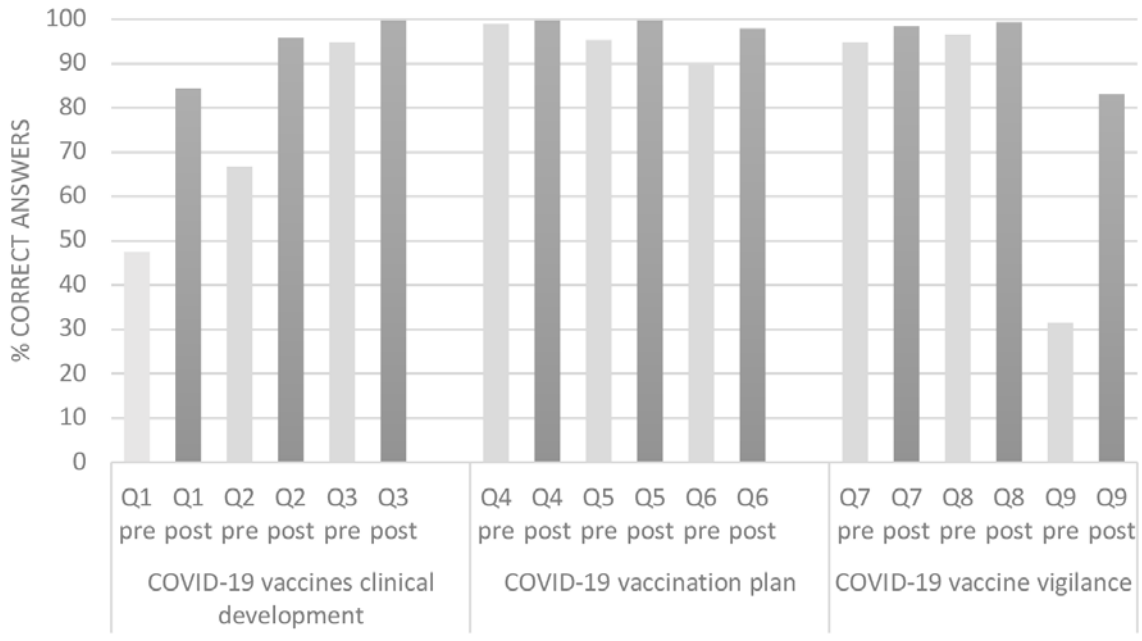
* t-student test for paired data.

Tab. IV. Distribution of correct answers for questions 1 to 9

Faculty	Medicine N=297		Pharmaceutical area N=90		Overall N=387	
	Pre	Post	Pre	Post	Pre	Post
Topic: "COVID-19 vaccines clinical development"						
Question 1 - The current COVID-19 vaccines authorized by AIFA in Italy are:						
mRNA, viral vector and subunit vaccines	154 (51.9)	273 (91.9)	30 (33.3)	54 (60.0)	184 (47.5)	327 (84.5)
Question 2 - Janssen vaccine contains:						
Human adenovirus type 26 as vector	204 (68.7)	290 (9.76)	54 (60.0)	81 (90)	258 (66.7)	371 (95.9)
Question 3 - The clinical development of COVID-19 vaccines:						
carried out all clinical research phases normally expected (phase I-III studies) with overlapping timelines	286 (96.3)	297 (100)	81 (90)	89 (98.9)	367 (94.8)	386 (99.7)
Topic: "COVID-19 vaccination plan"						
Question 4 - In the national strategic plan for the prevention of SARS-CoV-2 infection, the target population to be vaccinated in the first phase were:						
Healthcare workers, long-term residents (RSA) and elderly people (> 80 years)	294 (99)	297 (100)	89 (98.9)	89 (98.9)	383 (99)	386 (99.7)
Question 5 -The use of COVID-19 vaccine in pregnancy status in Italy is currently:						
Recommended	286 (96.3)	294 (76)	83 (92.2)	89 (98.9)	369 (95.3)	383 (99.7)
Question 6 - The extension of compulsory COVID-19 vaccination currently concerns:						
People over the age of 50 years	273 (91.9)	294 (99)	74 (82.2)	85 (94.4)	347 (89.7)	379 (97.9)
Topic: "COVID-19 vaccine vigilance"						
Question 7 – Most of Adverse Events Following Immunization (AEFI) reported for COVID-19 vaccines were:						
Not serious with complete recovery	285 (96)	296 (99.7)	82 (91.1)	85 (94.4)	367 (94.8)	381 (98.4)
Question 8 - The most reported AEFIs were:						
Fever, tiredness, injection site pain	288 (97)	297 (100)	86 (95.6)	88 (97.8)	374 (96.6)	385 (99.5)
Question 9 - The most AEFI for the COVID-19 vaccine concerned the administration of:						
Comirnaty	98 (33)	269 (90.6)	24 (26.7)	53 (58.9)	122 (31.5)	322 (83.2)

Pre: refers to pre-course test; Post: refers to post-course test. AIFA: Italian Medicines Agency. Correct answers: n (%).

Fig. 1. Overall distribution (%) of correct answers in pre- and post-course tests grouped by topic.



in the COVID-19 vaccination campaign, we observed a low number of incorrect answers in the pre-course test and almost none in the post-course test. On the other hand, for pharmaceutical area students, we highlighted a greater reduction limited to: Q11 - "Which of the following stages of COVID-19 vaccination is the pharmacist involved in?" (from 21% to 6.6%) and Q12 – "Which of the following COVID-19 vaccines is administered by the pharmacist?" (from 38.9% to 12.2%). An opposite trend was observed for "Q10 – In the COVID-19 vaccination campaign the pharmacist has played a crucial role" (Tab. V).

Discussion

The aim of this study was to evaluate the knowledge of medical and pharmaceutical area students regarding COVID-19 vaccines and vaccination strategies and the impact of an Elective Teaching Activity on students' knowledge. More specifically, this study mainly focused on the efficacy of non-curricular and specific academic courses on the topic of vaccinations as an innovative learning tool for health-area students. As future medical and pharmaceutical area students will become healthcare professionals who play a prominent role in administering

Tab. V. Distribution of incorrect answers given in both tests.

Incorrect answers	Overall N = 387		Medicine N = 297		Pharmaceutical area N = 90	
	Pre	Post	Pre	Post	Pre	Post
Topic: "COVID-19 vaccines clinical development						
Question 1 - The current COVID-19 vaccines authorized by AIFA in Italy are:						
mRNA vaccines and viral vector vaccines	164 (42.4)	51 (13.2)	124 (41.8)	22 (7.4)	40 (44.4)	29 (32.2)
Only mRNA vaccines	28 (7.2)	7 (1.8)	15 (5.1)	1 (0.3)	13 (14.4)	6 (6.7)
mRNA vaccines and live attenuated vaccines	11(2.8)	2 (0.5)	4 (1.3)	1 (0.3)	7 (7.8)	1 (1.1)
Question 2 - Janssen vaccine contains:						
Monkey Adenovirus type 26 as vector	47 (12.1)	10 (2.6)	36 (12.1)	4 (1.3)	11(12.2)	6 (6.7)
SARS-CoV-2 Spike protein inserted into a vector	65 (16.8)	4 (1.0)	43 (14.5)	1 (0.3)	22 (24.4)	3 (3.3)
Human Adenoviruses type 25 and 26 as vector	15 (3.9)	1 (0.3)	13 (4.4)	1 (0.3)	2 (2.2)	-
Question 3 - The clinical development of COVID-19 vaccines:						
Was based only on phase II and III studies on a limited number of volunteers for time constraints	10 (2.6)	-	7 (2.4)	-	3 (3.3)	-
Was based only on phase III studies for time constraints	2 (0.5)	-	2 (0.7)	-	-	-
Did not follow all the same clinical research phases normally expected (phase I-III studies) but a completely different clinical trial	7 (1.8)	-	2 (0.7)	-	5 (5.6)	-
Topic: "COVID-19 vaccination plan"						
Question 4 - In the national strategic plan for the prevention of SARS-CoV-2 infection, the target population to be vaccinated in the first phase was:						
People aged 60 to 75 years	4 (1.0)	1 (0.3)	3 (1.0)	-	1 (1.1)	1 (1.1)
Prisoners	-	-	-	-	-	-
Teachers and school staff	-	-	-	-	-	-
Question 5 - The use of the COVID-19 vaccine in pregnancy status, in Italy is currently:						
Mandatory	2 (0.5)	2 (0.5)	1 (0.3)	1 (0.3)	1 (1.1)	1 (1.1)
None of the other answers	10 (2.6)	2 (0.5)	6 (2.0)	2 (0.7)	4 (4.4)	-
Contraindicated	6 (1.6)	-	4 (1.3)	-	2 (2.2)	-
Question 6 - The extension of compulsory COVID-19 vaccination currently concerns:						
Pregnant women	-	2 (0.5)	-	1 (0.3)	-	1 (1.1)
People over the age of 80 years	5 (1.3)	-	3 (1.0)	-	2 (2.2)	-
People over the age of 12 years	35 (9.0)	6 (1.6)	21 (7.1)	2 (0.7)	14 (15.6)	4 (4.4)
Topic: "COVID-19 vaccine vigilance"						
Question 7 - Most of the AEFI reported for COVID-19 vaccines were:						
Fatal	1 (0.3)	-	1 (0.3)	-	-	-
Severe	7 (1.8)	3 (0.8)	5 (1.7)	1 (0.3)	2 (2.21)	2 (2.2)
Sever with full recovery	12 (3.1)	3 (0.8)	6 (2.0)	2 (2.2)	6 (6.7)	3 (3.3)
Question 8 - The most reported AEFI was:						
Central venous sinus thrombosis	8 (2.1)	1 (0.3)	5 (1.7)	-	3 (3.3)	1 (1.1)
Myocarditis	5 (1.3)	1 (0.3)	4 (1.3)	-	1 (1.1)	1 (1.1)
Bell's palsy	-	-	-	-	-	-
Question 9 - The most AEFI for the COVID-19 vaccine concerned the administration of:						
Moderna vaccine	88 (22.7)	25 (6.5)	65 (21.9)	11 (3.7)	23 (25.6)	14 (15.6)

▶

Tab. V. *Continues..*

Incorrect answers	Overall N = 387		Medicine N = 297		Pharmaceutical area N = 90	
	Pre	Post	Pre	Post	Pre	Post
Janssen vaccine	96 (24.8)	26 (6.7)	77 (25.9)	13 (4.4)	19 (21.1)	13 (14.4)
Spikevax vaccine	79 (20.4)	13 (3.4)	56 (18.9)	4 (1.3)	23 (25.6)	9 (10.0)
"The role of the medical specialist in public health in COVID-19 vaccination" (for medical students)						
Question 10 - Which, among these, is an operational line proposed by the strategic plan of the Ministry of Health to reach the target values of the vaccination campaign?						
Supply and distribution	-	-	8 (2.7)	1 (0.3)	-	-
Needs monitoring	-	-	3 (1.0)	-	-	-
Administration of vaccinations at the local level	-	-	11 (3.7)	1 (0.3)	-	-
Question 11 - What are the responsibilities of the medical specialist in public health during the vaccination session according to the organizational layout of the region of Tuscany?						
Sanitization of vaccination boxes	-	-	-	-	-	-
Recording vaccinations on the vaccination register	-	-	2 (0.7)	-	-	-
Implementation of the preparatory activities for the management of the vaccination session	-	-	21(7.1)	4 (1.3)	-	-
Question 12 - The COVID-19 vaccination task force of the Local Health Unit (LHU) of Central Tuscany:						
Independently manages the organization of vaccination agenda	-	-	8 (2.7)	-	-	-
Refers to the Allergology and Immunology SOS to manage the operating procedures of vaccinations in a protected setting	-	-	5 (1.7)	-	-	-
is independent of the General Management of the region of Tuscany	-	-	3 (1.0)	-	-	-
"The role of the pharmacist in COVID-19 vaccination" (for pharmaceutical degrees students)						
Question 10 - In the COVID-19 vaccination campaign the pharmacist has played a crucial role:						
In community pharmacy	-	-	-	-	30 (33.3)	34 (37.8)
In hospital pharmacy	-	-	-	-	1 (1.1)	1 (1.1)
In vaccination hubs	-	-	-	-	4 (4.4)	-
Question 11 - Which of the following stages of COVID-19 vaccination is the pharmacist involved in?						
Storage and conservation in the pharmacy	-	-	-	-	2 (2.2)	2 (2.2)
Dispensing in pharmacies (to general practitioners)	-	-	-	-	4 (4.4)	1 (1.1)
Administration in the pharmacy (to patients)	-	-	-	-	13(14.4)	3 (3.3)
Question 12 - Which of the following COVID-19 vaccines is administered by the pharmacist?						
Moderna	-	-	-	-	13 (14.4)	2 (2.2)
Janssen	-	-	-	-	15 (16.7)	3 (3.3)
Spikevax	-	-	-	-	7 (7.8)	6 (6.7)

Pre: refers to pre-course test; Post: refers to post-course test. AIFA: Italian Medicines Agency. Incorrect answers: n (%).

or producing/commercializing vaccines, it is important to provide them with comprehensive knowledge. This will be crucial in preventing the emergence of vaccine hesitancy and ensuring confidence in vaccinations in the future. However, this study did not focus on estimating vaccine hesitancy among this group of students, but rather on the efficacy of increasing their knowledge by specific educational tools on vaccinations and COVID-19 vaccines. It is relevant to highlight that this training course was performed one year after the first immunization campaign in Italy, hence the interest in assessing students' knowledge of the various COVID-19 vaccines present at the time of the course delivery.

The results obtained suggest that the basic level of knowledge of both healthcare area students on COVID-19 vaccination was very good for medical students and fair for pharmaceutical area students. This data could be attributed to the fact that medical students were attending the last years of the medical course (from IV to VI year), while the other students were enrolled in previous academic years.

The ETA proved to be highly effective in improving the students' knowledge of COVID-19 vaccination. Despite already achieving good overall scores on the first test, all students were able to significantly increase their final score (overall +17.1%).

The questionnaire was not previously published as it was based on all the topics covered during the course. Nevertheless, these findings are comparable with the results obtained from students participating in a previous ETA on vaccines and general vaccination strategies at the same university in the first months of 2021 at the start of the COVID-19 vaccination campaign [17]. In this last case, the population of

students also included medical postgraduate students, and a different distribution in the number of medical and pharmacy students was observed. A total of 449 students participated in the previous ETA on vaccines and vaccinations, comprising 165 students (36.8%) enrolled in Pharmacy, 261 students (58.1%) in Medicine, and 23 students (5.1%) in the postgraduate school of Hygiene and Preventive Medicine. The majority of the students were females (n = 301, 67.0%) and were in their fourth or fifth year of the academic course, just as in the 2022 course. Although the questions were different from the 2022 course edition, a comparison in terms of increased knowledge was possible. Both pharmacy and medicine students showed a significant increase in their test scores between the pre- and post-course tests. A higher increase of more than +27% was observed and it was reported by both student groups (pharmacy students increased from 19.2/32 to 26.8/32 and medical students increased from 22.0/32 to 30.1/32, $p < 0.001$) [16]. Maybe the higher basic level of knowledge reported by the students in this last ETA could be attributed to increased attention to the specific topic of COVID-19 vaccination. This activity was offered and delivered during the fourth wave of the COVID-19 pandemic in Italy and specifically, this study was conducted one year after the beginning of the Italian COVID-19 booster mass vaccination. Indeed, the ETA was realised when about 80% of the Italian population received the second vaccine dose and 27.5% the third vaccine shot [18]. It is possible that the timing of the study could partially explain the high interest in the course and the significant improvement in knowledge demonstrated by the students in their test scores.

The ETA has also included a section dedicated to the role of the medical specialist in public health and pharmacist in the COVID-19 immunization campaign, in Italy.

The results of the current study show that, when comparing the pre- and post-course test scores, medical students demonstrated a better comprehension of the role of the medical specialist in public health in the COVID-19 vaccination campaign with very low percentages of wrong answers per question. Instead, some uncertainties were observed on the role of pharmacist in the vaccination campaign. As a matter of fact, vaccination was implemented for the first time in pharmacies in Italy during the emergency immunization campaign against SARS-CoV-2 [19]. Given the results of this study, a particular consideration should be dedicated to the training of future pharmacists, not only in the distribution and storing of vaccines, but also in the direct administration of vaccines. In the near future, the role of pharmacists in the administration phases could be extended to other vaccinations, as happens in other European countries [20]. On the other hand, pharmacists still represent a relevant source of information on immunization, thanks to their closeness to customers.

Improvement in students' knowledge obtained in the post-course test was also demonstrated by the overall decrease in the number of incorrect answers in both groups of students. Therefore, this type of ETA proves to be useful also in tackling misinformation about COVID-19.

If we consider the international context, a recent scoping review revealed that medical students who showed hesitancy to receive COVID-19 vaccines were found to have a lack of knowledge regarding the importance of vaccinations against COVID-19. Moreover, it is also important to assess vaccine reluctance at a local level to allow medical schools to develop strategies tailored to their specific needs to encourage vaccination [21].

This study has some limitations. As mentioned earlier, it is important to note that the course was not mandatory, but rather optional. This can explain why the sample size is relatively small considering the total number of students enrolled in medical and pharmacy degree programs at the University of Florence.

Secondly, the questionnaire was not validated, and questions were developed to address all the topics covered during the course. In addition, administering a pre-test may lead to heightened awareness and focus on the test material among test-takers, potentially leading to an emphasis on achieving higher scores rather than gaining a comprehensive understanding of the subject matter. Lastly, the current study design may result in an overestimation of the intervention's efficacy due to some factors such as the regression to the mean and temporal effects.

Our results suggest a certain interest in vaccination topics by healthcare area students. In recent years, similar extracurricular activities about vaccines were included in the Italian educational system with a positive response [22-23]. Furthermore, well-trained students will have a key role in promoting vaccinations and increasing public trust [24]. Finally, their role can be more effective using innovative forms of communication [25]. In the future, a thorough evaluation of the long-term effectiveness of this type of course (*e.g.*, assess whether the students can recall most information or simulate correct actions following the most up-to-date recommendations one year after the training) could be useful to decide on possible changes to the activities, or set retraining.

Conclusions

This ETA, held one year after the COVID-19 immunization campaign, was conducted to offer students in healthcare settings an insight into available COVID-19 vaccines and new technologies applied to their development, topics that are not always extensively covered in the curriculum courses. Another goal of this ETA was to inform medical and pharmaceutical area students on the current role of the medical specialist in public health and the pharmacist in the COVID-19 vaccination campaign. The findings of this study show that the offer of advanced training courses on specific levels of vaccination prevention is effective in improving the knowledge of future health professionals, who will

be the main source of information for the population. Moreover, following the training, it will be appropriate to continue education with specific courses on communication and vaccine-counselling skills.

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Informed consent statement

The study was conducted according to the guidelines of the Declaration of Helsinki. Ethical approval was waived for this study, due to the deidentified nature of the data presented.

Conflict of interest statement

The authors have no conflicts of interest to declare.

Authors' contributions

AB, SB, AV: conceptualization. AB, SB, JS, CS: methodology. CS, JS: formal analysis. GC, NL, AV, AB, SB: investigation. AB, SB, CS: data curation. CS: writing-original draft preparation. GC, NL, AV, AB, SB, MDR, FC, JS, PB writing-review and editing. All authors have read and agreed to the published version of the manuscript.

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