Vaccine 37 (2019) 6900–6906

Contents lists available at ScienceDirect

Vaccine

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

Healthcare workers' knowledge, beliefs, and coverage regarding vaccinations in critical care units in Italy

Francesco Napolitano [a], Aida Bianco [b], Alessia D'Alessandro [a], Rosa Papadopoli [b], Italo Francesco Angelillo [a,*]

[a] Department of Experimental Medicine, University of Campania "Luigi Vanvitelli", Via L. Armanni, 5, 80138 Naples, Italy
[b] Department of Health Sciences, University of Catanzaro "Magna Græcia", Via T. Campanella, 115, 88100 Catanzaro, Italy

ARTICLE INFO

Article history:
Received 22 January 2019
Received in revised form 5 September 2019
Accepted 16 September 2019
Available online 26 September 2019

Keywords:
Critical care units
Healthcare workers
Hospital
Recommended vaccinations
Survey
Vaccinations coverage

ABSTRACT

Background: Low rates of vaccine coverage have resulted in a resurgence of several vaccine-preventable diseases in many European countries. Routine vaccination of healthcare workers (HCWs) is important to reduce disease transmission, and to promote vaccine awareness and acceptance in the population. The objectives of this cross-sectional study were to investigate knowledge and beliefs about vaccines and to evaluate self-reported immunization coverage with vaccines recommended for HCWs. Additionally, the effects of several factors on these outcomes have been evaluated.

Methods: A survey was conducted between September and November 2018 among a random sample of HCWs in cardiac, adult, and neonatal critical care units of 8 randomly selected hospitals across the Campania and Calabria Regions in Italy. Multivariate logistic and linear regression analysis has been performed.

Results: A total 531 HCWs returned the questionnaire for a response rate of 54.9%. Based on a vaccination knowledge score ranging from 0 to 9, more than half of the participants (55.4%) knew few of the vaccines recommended for HCWs (≤3 correct answers), 16.2% knew some vaccines (4–6 correct answers), and 28.4% knew most vaccines (≥7 correct answers), and only 13.2% knew all the vaccines recommended for HCWs. However, two-thirds (62.2%) knew that hepatitis B and influenza vaccines were recommended, and this knowledge was significantly higher among females ($p < 0.001$), among HCWs aged between 50 and 59 years ($p = 0.01$) compared with those aged < 30 years, and in those who search for information about recommended vaccines for HCWs ($p = 0.012$). The vaccine knowledge was significantly lower among nurses and nursing supporting staff compared with physicians ($p = 0.032$). Approximately two-thirds (62.7%) of HCWs considered themselves at risk of contracting vaccine-preventable infectious diseases during their professional practice. High rates of coverage were self-reported for hepatitis B (96.3%), tetanus and pertussis (93.7%), whereas they were lower for measles/mumps/rubella (80.5%), chickenpox (65.3%), and influenza (35.8%). Only 9.2% of HCWs reported prior receipt of all recommended vaccines. Male HCWs were less likely to report prior receipt of all recommended vaccines ($p = 0.011$). HCWs aged between 30 and 39 years compared with those aged < 30 years ($p = 0.001$) and those who knew some ($p < 0.001$) and most ($p = 0.007$) of all vaccines recommended for HCWs were more likely to self-report to be immunized.

Conclusions: Additional training about the vaccinations is needed to improve HCWs knowledge and to address specific concerns which may lead to better uptake among this group.

1. Introduction

Healthcare workers (HCWs) are one of the most at-risk groups for acquiring infectious diseases and transmitting them to other hospital staff and to patients [1,2]. Their vaccination is an important public health measure for infection control to reduce lost of work productivity and employee absenteeism, and related morbidity and mortality particularly among high-risk patients [3–5]. A

Abbreviations: HCWs, healthcare workers; MMR, measles/mumps/rubella; Td/Tdap, tetanus/diphtheria/pertussis; CCUs, critical care units; VPD, vaccine-preventable infectious disease.

* Corresponding author at: Department of Experimental Medicine, University of Campania "Luigi Vanvitelli", Via Luciano Armanni, 5, 80138 Naples, Italy.
E-mail address: italof.angelillo@unicampania.it (I.F. Angelillo).

https://doi.org/10.1016/j.vaccine.2019.09.053
0264-410X/

variety of strategies to improve disease awareness, to address concerns about vaccine safety and effectiveness, and to increase vaccine accessibility have been recommended to improve vaccine coverage among HCWs [1,2,5,6]. In Italy, hepatitis B, influenza, measles/mumps/rubella (MMR), varicella, and pertussis are the vaccines recommended for all HCWs [6]. However, despite clinical evidence demonstrating the safety and efficacy of these vaccinations, vaccine acceptance among HCWs is relatively low [7,8].

Current guidelines from health departments and professional organizations in various countries strongly recommended HCWs' vaccinations against hepatitis B, influenza, MMR, chickenpox, tetanus/diphtheria/pertussis (Td/Tdap), and meningococcal disease especially for those working in critical care units (CCUs). In Italy, in recent years suboptimal vaccination coverage in the general population resulted in an increase, for example in measles cases. Therefore, improving HCWs' vaccination is an important element in order to be effective communicators on the value of vaccination [9–11].

In spite of the number of published studies on HCWs in ICUs reporting their level of knowledge, attitudes, and practices regarding vaccinations conducted in different countries [12–15], to the best of our knowledge, there is a lack of such research in Italy [16–18]. Investigating this topic could provide useful information in order to tailor interventions to increase vaccination coverage among this at-risk population. Therefore, the findings of this study can be used as a basis for designing and delivering a public health service plan tailored for our country and its cultural environment in an effective and efficient way. Consequently, the current survey conducted among a large sample of HCWs in the CCUs in Italy seeks to fill this gap in the literature and to achieve two main objectives. First, to investigate the knowledge, beliefs, and immunization coverage, and second to explore the effects of several factors on these outcomes of interest.

2. Materials and Methods

2.1. Setting and recruitment procedures

This was a cross-sectional survey conducted between September and November 2018. A total of 8 public hospitals (range of number of beds, 123–936) which serves a population of about 3 million people, with cardiac, adult, and neonatal CCUs across the Campania and Calabria Regions in Italy, were randomly selected. None of the hospitals had a HCWs vaccination policies in place at the time of the survey. All active health care personnel working as HCWs in such units of the selected hospitals were informed of the survey and invited to participate.

The sample size estimate for survey distribution was selected based on previously reported rates of influenza vaccine coverage among HCWs and a hypothesized 40% of HCWs immunized [8,13], a 95% confidence interval, and a margin error of 5%. Therefore, the minimum sample size required was 370 HCWs. Also, accounting for a response rate of 60%, the minimum sample size that was required was 520.

An information letter was sent to the hospital directors explaining the objectives and methodology of the survey in order to obtain their approval to conduct the study. After approval was received, the research team distributed the questionnaire to all HCWs, including a cover letter explaining the purpose of the study, that participation was voluntary, and assuring that full confidentiality would be maintained. Anonymization of any personal identifiers or situations were granted. A written informed consent form was also included to process personal data, and an envelope to return the questionnaire to the research team. In order to maximize the response rate, the research team went every three days to the CCUs to collect the completed questionnaires and to again offer the questionnaire to any participants who may have lost it. There were no incentives offered to those who participated in the survey.

2.2. Design and administration of the questionnaire

The questionnaire, developed by the research team, was pilot tested prior to the start of the survey, in order to ensure that the questions were understood as intended and to omit questions that were misinterpreted. A convenience sample of 20 HCWs working in the CCUs was used. Data from the pilot were not included in the final analysis.

The structured questionnaire was self-administered and consenting participants were asked to answer questions on the following five themes: (1) socio-demographic and professional characteristics (gender, age, marital status, number of children, occupation, work place, years in practice, previous practice in other unit areas); (2) knowledge regarding the vaccines recommended for the HCWs; (3) perception of the risk of contracting a vaccine-preventable infectious disease (VPD) during professional practice, and beliefs about the usefulness of the recommended vaccines for HCWs and patients' health; (4) self-reported vaccination coverage with the recommended vaccines; and (5) sources of information used for searching for information about the vaccines recommended for HCWs, and the need for additional information.

The section about knowledge included nine close-ended questions about which vaccines were recommended for HCWs that could be answered as 'yes', 'no', or 'do not know'. An overall knowledge score was calculated by giving for each question a value of '1′ for a correct response and a value of '0′ for an incorrect or 'do not know' response. The range was from zero to 9 points for a given participant. A respondent who achieved a score greater than or equal to 7 was categorized as knowing most of the recommended vaccines, 4–6 score as knowing some, and 0–3 as knowing few. Response options for all belief variables used a 10-point Likert scale with higher values corresponding to a more strongly agree with the statement [19–22]. The vaccination coverage was explored asking whether the participant had received the recommended vaccines and the response option included "yes", "no", and "do not know". The HCW was asked to indicate from a list of options the reason(s) for having or not having received each vaccine.

Ethical approval was obtained prior to initiation of the study from the Ethics Committee of the Teaching Hospital of the University of Campania "Luigi Vanvitelli".

2.3. Data analysis

The data obtained from the questionnaire were analyzed using Stata software version 15 [College Station, TX: StataCorp LLC]. First, descriptive statistics, including frequencies, means, and standard deviations, summarized demographic information, knowledge and belief about vaccines data, and the immunization coverage levels of the sample. Second, chi-square and Student's t-test were used to test the association between the independent variables and the following three outcomes of interest: knowledge that the hepatitis B and influenza vaccines are recommended for HCWs; perceived risk of contracting a VPD during professional practice; and immunization coverage with all vaccines recommended for HCWs. All independent variables with a p-value less or equal than 0.25 were considered eligible for inclusion into the multivariate regression analysis. Third, multivariate logistic and linear regression models were used to investigate independent characteristics associated with the already mentioned outcomes of interest regarding the knowledge (Model 1); perceived risk (Model 2); and immunization coverage (Model 3). The following independent

variables were included in all Models: gender (male = 0; female = 1), age, in years (<30 = 1; 30–39 = 2; 40–49 = 3; 50–59 = 4; ≥60 = 5), occupation (nurse/nursing supporting staff = 0; physician = 1), work place (cardiac CCU = 1; adult CCU = 2; neonatal CCU = 3), number of years in practice (continuous), and searching for information sources about the vaccines recommended for the HCWs (no = 0; yes = 1). In Models 2 and 3, the variable knowledge of the vaccines recommended for HCWs (few = 1; some = 2; most = 3) was also included. In Model 2, the independent variable previous professional practices in other unit locations (no = 1; critical = 2; medical = 3; surgical = 4) was also included. In Model 3, the belief in the usefulness of the vaccines recommended for HCWs to protect themselves (continuous) and attitude towards efficacy of vaccinations on patients' health (continuous) were also included.

A stepwise procedure was applied to obtain the final models with p values for the variable inclusion and exclusion of >0.2 and <0.4, respectively. The results of the logistic regression analysis are expressed as odds ratios (ORs) and their 95% confidence intervals (CIs). Standardized regression coefficients (β) were presented in the linear regression model. A two-tailed p-value of less than 0.05 was considered significant for all analyses.

3. Results

Out of 967 HCWs that were approached, 531 completed and returned the questionnaire with a response rate of 54.9%. According to the occupation, the response rates were 47.7% for physicians (155/325), 56.4% for nurses (315/558), and 72.6% for nursing supporting staff (61/84). Table 1 shows the socio-demographic and professional characteristics of the participants. The majority of the respondents were women (57.1%), the mean age was 45.2 years, 69.1% were married, more than half were nurses, worked in an adult critical care unit, and the mean time spent working in CCUs was 11.2 years.

Table 1
Main characteristics of the study population.

Characteristic	*n*	%
Gender		
Female	296	57.1
Male	222	42.9
Age, years		
Mean ± Standard deviation	45.2 ± 10.5	
Median (range)	46 (19–66)	
Marital status		
Married	253	69.1
Unmarried/ widowed/separated/divorced	158	30.9
Number of children		
Mean ± Standard deviation	1.9 ± 0.7	
Median (range)	2 (0–5)	
0	129	28.7
1	69	15.4
>1	251	55.9
Occupation		
Nurses	315	59.3
Physicians	155	29.2
Nursing supporting staff	61	11.5
Work place		
Adult critical care unit	303	57.2
Neonatal critical care unit	147	27.7
Cardiac critical care unit	80	15.1
Length of time spent working in critical care units, years		
Mean ± Standard deviation	11.2 ± 9.9	
Median (range)	12 (1 month-41 years)	
Previous professional practices in other unit locations		
No	272	51.2
Critical	98	18.5
Surgical	89	16.8
Medical	72	13.5

Number for each item may not add up to total number of study population due to missing value.

3.1. Knowledge about vaccination

Table 2 shows the study participants' knowledge regarding the vaccines recommended for HCWs. The majority correctly identified hepatitis B (90.9%) and influenza (64.1%) vaccines as recommended for HCWs, whereas a very low number of HCWs indicated measles (41.9%), mumps (32.4%), rubella (34.1%), varicella (32.9%) or pertussis (31.1%) vaccinations. Only a very small proportion of HCWs correctly knew that hepatitis A (15.8%), pneumococcal (11.5%), meningococcal (8.5%), and tuberculosis (6.4%) vaccinations were not routinely recommended for Italian HCWs. The mean knowledge score was 4.1 ± 2.9 (sd) and the median value was 3. More than half of the participants (55.4%) knew few of the vaccines recommended for HCWs, 16.2% knew some vaccines, and 28.4% knew most vaccines. Only 13.2% of HCWs knew all the vaccines that are recommended for them, and 5.6% did not answer any of the questions correctly.

Almost two-thirds of respondents (62.2%) knew that both hepatitis B and influenza vaccines are recommended for HCWs. Since the level knowledge of all recommended vaccines was lower than expected, the knowledge that hepatitis B and influenza vaccines are recommended was chosen as outcome of interest. The results obtained from the multivariate logistic regression model showed that four correlates were statistically significant associated with this knowledge. Knowledge was significantly higher among females (OR = 2.05; 95% CI 1.39-3.02), in those aged between 50 and 59 years (OR = 1.82; 95% CI 1.15–2.87) compared with those < 30 years, and in those who search for pursued information about recommended vaccines for HCWs (OR = 2.22; 95% CI 1.19-4.13). The professional role had a significant negative association with this knowledge, with nurses and nursing supporting staff being less aware of the need for hepatitis B and influenza vaccinations (OR = 0.62; 95% CI 0.4-0.96) compared with physicians (Model 1 in Table 3).

3.2. Beliefs in vaccination

Only 62.7% of HCWs considered themselves at high-risk of contracting a VPD during their professional practice. On a scale from 1 to 10, with 10 representing a high perception of risk, respondents obtained a mean score of 6.4. Multiple linear regression analysis showed that HCWs aged between 40 and 49 years had a higher perception of risk of acquiring a VPD ($t = 2.26$, $p = 0.024$) compared with those <30 years, whereas, those aged ≥60 years had a lower perception ($t = -2.1$, $p = 0.037$). In addition, staff working in a neonatal CCU had a lower perception of risk of contracting a VPD by vaccination during their activity compared with those in a cardiac CCU ($t = -2.72$, $p = 0.007$) (Model 2 in Table 3). Participants had a strongly positive attitude regarding the usefulness of the vaccinations recommended for HCWs to protect themselves and the patients, with mean values of 8.7 and 8.4 respectively.

3.3. Immunization coverage

Table 4 shows the self-reported vaccination coverage of the study participants according to the occupation. The vaccination coverage for hepatitis B (96.3%) and tetanus and pertussis (93.7%) were high, but lower for MMR (80.5%), chickenpox (65.3%), and influenza (35.8%). Only 9.2% of HCWs reported prior receipt of all recommended vaccines. Reasons identified by respondents for

Table 2
Correct responses regarding the recommended vaccinations for HCWs of the study population.

Which vaccination is recommended for HCWs? (correct response)	**Total (n = 531)**	**Occupation**			**Work place**			**Number of years in practice**		
		Nurses (n = 315)	Physicians (n = 155)	Nursing supporting staff (n = 61)	Adult critical care unit (n = 303)	Neonatal critical care unit (n = 147)	Cardiac critical care unit (n = 80)	<1 (n = 78)	1–10 (n = 194)	>10 (n = 232)
Recommended vaccination	%	%	%	%	%	%	%	%	%	%
Hepatitis B	90.9	91.6	94.8	83.3	90.8	89.8	93.7	94.9	88.1	93.1
Influenza	64.1	64	72.2	48.3	60.7	66	72.5	65.4	63.4	65.9
Tetanus	52.7	50.8	58	53.3	47.8	57.1	62.5	64.1	55.1	46.5
Measles	41.9	39.9	51	28.3	37	51	43.7	53.8	42.3	37.1
Rubella	34.1	34.1	38.7	28.3	30.4	41.5	33.7	47.4	36.1	27.6
Varicella	32.9	33.8	34.4	30	28.4	40.1	36.2	43.6	35.1	26.3
Mumps	32.4	31.8	38.7	21.7	30.4	34.7	35	44.9	30.4	28.4
Pertussis	31.1	29.9	38.7	20	25.7	41.5	31.2	37.2	30.9	28.9
Diphtheria	30.7	27	41.9	23.3	27.4	34	36.2	33.3	28.9	30.8
Other vaccination										
Hepatitis A	15.8	12.2	27.7	5	18.8	8.8	17.5	20.5	17	13.8
Poliomyelitis	11.5	11.6	14.2	5	11.5	12.2	10	14.1	14.9	8.2
Pneumococcal disease	11.5	10.9	14.8	6.6	12.9	8.2	12.5	16.7	11.3	9.9
Meningococcal disease	8.5	7.4	10.9	8.3	10.2	4.8	8.7	7.7	8.8	9
Tuberculosis	6.4	4.8	9.7	6.6	6.9	6.8	3.7	12.8	7.2	4.3

Number for each item may not add up to total number of study population due to missing value.

non-vaccination included: perception of not being at risk for disease (51.2%), fear of vaccine adverse effects (24.7%), and a mistrust of vaccines (15.9%). Of respondents who declined the varicella vaccine, 42.4% did not consider themselves at high risk for disease and 21.2% feared potential vaccine side effects. The main reason given by the HCWs for not being vaccinated for the seasonal influenza vaccination was that they did not consider themselves at high risk for developing influenza (61.4%); other reasons cited were the fear of potential vaccine side effects (18.6%) and the mistrust of vaccines (11.6%).

Since a possible interaction between age, occupation, and number of years in practice and immunization coverage has been hypothesized, the interaction term was initially included in the multivariate model and subsequently removed from the final logistic regression model because it was not statistically significant.

The only three factors showing a significant influence on self immunization coverage were age, gender, and knowledge regarding the vaccines recommended for HCWs. HCWs aged between 30 and 39 years (OR = 6.26; 95% CI 2.18-18.04), compared with those aged <30 years, had a higher self-reported vaccine coverage, whereas male HCWs were less likely to be immunized (OR = 0.41; 95% CI 0.21-0.81). The level of knowledge, as expected, was the most significant predictor of immunization coverage, since participants who knew some (95% CI 2.16-11.24) or most (95% CI 1.38-8.27) of all recommended vaccines had 4.92 and 3.39 times the odds, respectively, of being immunized with all recommended vaccinations compared to those who knew few vaccines (Model 3 in Table 3).

3.4. Sources of information

The majority of the respondents considered the Internet as the major source in seeking information (46.2%), followed by scientific journals (39.6%), congress/educational courses (30.7%), colleagues (26%), and professional associations (19.2%). Nearly two-thirds of respondents (61.2%) expressed interest in more education regarding immunizations.

4. Discussion

This study was designed to obtain information about vaccine knowledge and beliefs, and HCW vaccine coverage, including influencing factors, among a large sample of Italian HCWs employed in CCUs. The findings have shown that the HCWs had a poor knowledge of all the vaccines that are recommended for them, a low perception of the risk for contracting a VPD during their work, and had reported an high vaccination coverage only against hepatitis B (96.3%).

We evaluated the participants' level of knowledge regarding the vaccines recommended for HCWs. Only 13.2% of HCWs knew all the vaccines recommended for them and 5.6% did not correctly identify which vaccines were recommended for HCWs. A majority of the sample indicated that hepatitis B and influenza were vaccines recommended for HCWs. Their knowledge of the recommendation for measles, varicella, and pertussis was much lower. These results are similar to those reported in previous investigations conducted among nurses in Austria [15] and occupational physicians in Germany [23]. Inadequate knowledge by HCWs may result in the transfer of false information to patients and the public. Therefore, the findings highlight the importance of implementing educational campaigns for HCWs on vaccination. HCWs have been consistently identified as the most influential and trusted source of information on vaccination [19–22,24]. And they are key facilitators for promoting vaccinations. There is a clear need for healthcare authorities and managers to plan educational campaigns for HCWs regarding the immunization in order to increase the coverage. Such improvement may be achieved through the utilization of fliers, newsletters, meetings, lectures, and by providing free and actively promoted vaccinations in the workplace with staff dedicated [25–27].We evaluated the participants' perception of the risk of acquiring a VPD while at work and their beliefs in the value of vaccination in reducing the likelihood of disease transmission. Only 62.7% considered themselves at risk of contracting a VPD while performing their job duties. Similar results were also reported in previous surveys in the UK with regards to influenza vaccination [28] and in China with regards to hepatitis B vaccination [12].

We evaluated self-reported vaccine coverage and found variation based on disease. There were high self-reported rates for hepatitis B (96.3%), tetanus and pertussis (93.7%) Suboptimal vaccine coverage among HCWs not only puts them at risk for disease, but puts their patients and colleagues at risk as well. Studies in other countries have reported similar rates of vaccine coverage for tetanus, hepatitis B, and influenza [14,15]. In contrast, for measles, pertussis, and hepatitis B the coverage in this study population were

Table 3
Multivariate analysis results.

Variable	OR	SE	95% CI	*p value*
Model 1: Knowledge that the hepatitis B and influenza vaccines are recommended for HCWs				
Log-likelihood = -300.16, χ^2 = 42.35, p value < 0.0001				
Gender				
Male	1*			
Female	2.05	0.4	1.39–3.02	<0.001
Age (years)				
<30	1*			
50–59	1.82	0.42	1.15–2.87	0.01
30–39	0.53	0.18	0.27–1.05	0.071
40–49	Backward elimination			
≥60	Backward elimination			
Searching for information sources about the vaccines recommended for the HCWs	2.22	0.7	1.19–4.13	0.012
Occupation				
Physicians	1*			
Nurse/Nursing supporting staff	0.62	0.14	0.4–0.96	0.032
Number of years in practice	Backward elimination			
Work place				
Cardiac critical care unit	1*			
Adult critical care unit	Backward elimination			
Neonatal critical care unit	Backward elimination			
Variable	**COEF.**	**SE**	***t***	***p value***
Model 2: Perceived risk of contracting a vaccine-preventable disease during professional practice				
F = 4.56, R^2 = 7.8%, adjusted R^2 = 6.1%, p value < 0.0001				
Work place				
Cardiac critical care unit	1*			
Neonatal critical care unit	−1.12	0.4	−2.72	0.007
Adult critical care unit	−0.56	0.36	−1.53	0.127
Age (years)				
<30	1*			
40–49	0.75	0.33	2.26	0.024
≥60	−0.64	0.3	−2.1	0.037
30–39	Backward elimination			
50–59	Backward elimination			
Knowledge of the vaccines recommended for HCWs				
Few	1*			
Most	0.57	0.3	1.89	0.059
Some	Backward elimination			
Searching for information sources about the vaccines recommended for the HCWs	0.65	0.42	1.53	0.126
Number of years in practice	−0.01	0.01	−1.53	0.127
Previous professional practice in other unit locations				
No	1*			
Surgical	0.43	0.34	1.23	0.218
Critical	Backward elimination			
Medical	Backward elimination			
Gender				
Male	1*			
Female	Backward elimination			
Occupation	Backward elimination			
Variable	**OR**	**SE**	**95% CI**	***p value***
Model 3: Immunization coverage with all vaccines recommended for HCWs				
Log-likelihood = -126.84, χ^2 = 43.83, p value < 0.0001				
Knowledge of the vaccines recommended for HCWs				
Few	1*			
Some	4.92	2.07	2.16–11.24	<0.001
Most	3.39	1.54	1.38–8.27	0.007
Age (years)				
<30	1*			
30–39	6.26	3.38	2.18–18.04	0.001
40–49	2.02	0.99	0.77–5.28	0.149
50–59	1.91	0.89	0.76–4.79	0.167
≥60	Backward elimination			
Gender				
Female	1*			
Male	0.41	0.14	0.21–0.81	0.011
Occupation				
Physicians	1*			
Nurses/Nursing supporting staff	1.65	0.65	0.75–3.59	0.209
Work place				
Cardiac critical care unit	1*			
Adult critical care unit	0.61	0.27	0.25–1.45	0.260
Neonatal critical care unit	Backward elimination			
Beliefs in the usefulness of the vaccines recommended for HCWs to protect themselves	0.87	0.13	0.64–1.16	0.348
Attitude towards efficacy of vaccinations on patients' health	0.87	0.13	0.64–1.17	0.361
Number of years in practice	Backward elimination			

* Reference category.

Table 4
Healthcare workers self-reported vaccination history.

Vaccination received	Nurses (n = 300)	Physicians (n = 152)	Nursing supporting staff (n = 59)	Total (n = 511)
	%	%	%	%
Hepatitis B	95.3	93.4	98.3	96.3
Diphtheria, tetanus, pertussis	90.8	95.4	91.4	93.7
Measles, mumps, rubella	58.3	42.9	64.4	80.5
Varicella	35.9	18.7	59.3	65.3
Tuberculosis	51.7	60.7	50	55.1
Influenza	31.5	45.7	30.4	35.8
Meningococcus C	31.6	31.1	41.4	32.7

Number for each item may not add up to total number of study population due to missing value.

higher than those self-reported in other settings [12,14,29–31]. These low coverage levels highlight the need for strong recommendations on the importance of HCW vaccination and readily accessible vaccines. Consistent with previous studies, this sample of HCWs reported several barriers for not being vaccinated: they did not consider themselves at risk for VPDs and they had uncertainty regarding the vaccines' safety [32–34]. These findings indicated that barriers and misbeliefs among HCWs need to be addressed urgently. There is the risk that those HCWs who are hesitant about vaccines may spread concerns to the public and recommend vaccines less frequently [24,35].

We evaluated the sources of vaccine information used by HCWs. There is a myriad of information available from different sources regarding vaccinations recommended for HCWs, which varies in credibility. Surprisingly, 46.2% indicated the Internet as their main source of vaccine information. Only 39.6% used scientific journals and 30.7% congress/educational courses as source of vaccine information. HCWs should be up to date with the latest evidence and information on VPDs. They should be directed to credible sources of information on vaccines, particularly those HCWs with a poor level of knowledge about immunization.

The final statement provided insight into the independent predictor of the different outcomes of interest. This study found that, among the different socio-demographic and professional factors, age, gender, and professional role predicted a participant's knowledge about recommendations for hepatitis B and influenza vaccines. The finding that older age had a positive influence on HCWs' knowledge may be related to the fact that with an increasing age, there is a greater likelihood of having seen cases of VPDs. As a result, a richer experience leads to greater knowledge. Furthermore, the significantly lower level of knowledge observed in nurses and nursing supporting staff may be partially because their education currently focuses mostly on patient care, with inadequate time given to vaccinations. Therefore, nursing education curriculum should be evaluated to ensure that adequate time is given to training regarding vaccines. This may also explain the lower vaccination rates of nurses compared with physicians seen in the present study and this is in accordance with previous studies that have found that physicians are more accepting of vaccines than other HCWs [30,36]. The second strongest predictor was having received information about the vaccines recommended for HCWs. HCWs who had received information were two times more likely to correctly identify that hepatitis B and influenza were vaccinations recommended for HCWs. Education is an important tool to improve vaccination coverage [37–39]. HCWs with greater vaccine knowledge were four times more likely to be vaccinated than HCWs with a low level of vaccine knowledge.

5. Limitations

It is important to mention that the results of the present study should be interpreted in the context of several potential limitations. First, because of the cross-sectional design, the study is only able to predict the general association between predictors and dependent variables, not temporality or causality. Second, the sample was selected from two geographic areas and, therefore, the results may be not entirely generalizable to all HCWs in Italy. Third, the survey instrument is new and had not been previously validated. Fourth, social desirability bias may also be a limitation. HCWs with positive attitudes toward vaccines may have been more likely to respond to the survey. Additionally, HCWs may have felt the need to provide socially desirable responses. This bias was limited by assuring participants that their responses would be anonymous and could not be back to them. Fifth, the vaccination status relies on self-reported data rather than record-review and the responses could have been affected by declaration or recall bias that may result in over- or underestimation. Despite these potential biases, the findings of this study provide useful information on the need for HCW education to improve knowledge and understanding of vaccines and vaccine uptake among HCWs in CCUs.

6. Conclusions

This study identifies gaps in knowledge and vaccination coverage among HCWs in CCUs in Italy. Therefore, it is crucial to plan educational campaigns for HCWs to improve their knowledge and to address specific concerns given the fact that those with greater knowledge were more likely to be vaccinated.

7. Contributors

FN and AB designed the study, were responsible for the data collection, performed the statistical analysis, and contributed to the interpretation; RP and ADA contributed to the data collection and interpretation; IFA the principal investigator, designed the study, was responsible for the data collection, statistical analysis and interpretation, and wrote the paper. All authors read and approved the final manuscript.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

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

Acknowledgements

The authors gratefully acknowledge the contribution of all HCWs that took part in this research.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2019.09.053.

References

[1] Advisory Committee on Immunization Practices; Centers for Disease Control and Prevention (CDC). Immunization of health-care personnel: recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2011; 60: 1-45.

[2] Centers for Disease Control and Prevention. Recommended vaccines for healthcare workers. https://www.cdc.gov/vaccines/adults/rec-vac/hcw.html [accessed 21 January 2018].

[3] Carman WF, Elder AG, Wallace LA, McAulay K, Walker A, Murray GD, et al. Effects of influenza vaccination of health-care workers on mortality of elderly people in long-term care: a randomised controlled trial. Lancet 2000;355:93–7.

[4] Burls A, Jordan R, Barton P, Olowokure B, Wake B, Albon E, et al. Vaccinating healthcare workers against influenza to protect the vulnerable is it a good use of healthcare resources? A systematic review of the evidence and an economic evaluation. Vaccine 2006;24:4212–21.

[5] WHO Position Papers – Immunization of health care workers, 2017. http://www.who.int/immunization/policy/Immunization_routine_table4.pdf [accessed 21 January 2018].

[6] Ministero della Salute. Piano Nazionale Prevenzione Vaccinale (PNPV) 2017-2019. https://www.salute.gov.it/imgs/C_17_pubblicazioni_2571_allegato.pdf [accessed 21 January 2018].

[7] To KW, Lai A, Lee KC, Koh D, Lee SS. Increasing the coverage of influenza vaccination in healthcare workers: review of challenges and solutions. J Hosp Infect 2016;94:133–42.

[8] Loulergue P, Moulin F, Vidal-Trecan G, Absi Z, Demontpion C, Menager C, et al. Knowledge, attitudes and vaccination coverage of healthcare workers regarding occupational vaccinations. Vaccine 2009;27:4240–3.

[9] Adamo G, Sturabotti G, Baccolini V, de Soccio P, Prencipe GP, Bella A, et al. Regional reports for the subnational monitoring of measles elimination in Italy and the identification of local barriers to the attainment of the elimination goal. PLoS ONE 2018;13:e0205147.

[10] Adamo G, Sturabotti G, de Soccio P, Prencipe GP, Sciarra I, Baccolini V, et al. The elimination of measles and rubella in Italy. Ig Sanita Pubbl 2017;73:429–42.

[11] Adamo G, Sturabotti G, D'Andrea E, Baccolini V, Romano F, Iannazzo S, et al. The end of measles and congenital rubella: an achievable dream? Ann Ig 2017;1:1–26.

[12] Liu Y, Ma C, Jia H, Xu E, Zhou Y, Zhang Z, et al. Knowledge, attitudes, and practices regarding hepatitis B vaccination among hospital-based doctors and nurses in China: Results of a multi-site survey. Vaccine 2018;36:2307–13.

[13] Blank DL, Bodansky DM, Forbes A, Garde E, Story F, Roalfe AK, et al. Influenza vaccination of future healthcare workers: a cross-sectional study of uptake, knowledge and attitudes. Vaccine 2010;28:4668–72.

[14] Little KE, Goodridge S, Lewis H, Lingard SW, Din S, Tidley M, et al. Occupational vaccination of health care workers: uptake, attitudes and potential solutions. Public Health 2015;129:755–62.

[15] Harrison N, Brand A, Forstner C, Tobudic S, Burgmann K, Burgmann H. Knowledge, risk perception and attitudes toward vaccination among Austrian health care workers: a cross-sectional study. Hum Vaccin Immunother 2016;12:2459–63.

[16] Albano L, Matuozzo A, Marinelli P, Di Giuseppe G. Knowledge, attitudes and behaviour of hospital health-care workers regarding influenza A/H1N1: a cross sectional survey. BMC Infect Dis 2014;14:208.

[17] Costantino C, Mazzucco W, Azzolini E, Baldini C, Bergomi M, Biafiore AD, et al. Influenza vaccination coverage among medical residents: an Italian multicenter survey. Hum Vaccin Immunother 2014;10:1204–10.

[18] Fortunato F, Tafuri S, Cozza V, Martinelli D, Prato R. Low vaccination coverage among italian healthcare workers in 2013. Hum Vaccin Immunother 2015;11:133–9.

[19] D'Alessandro A, Napolitano F, D'Ambrosio A, Angelillo IF. Vaccination knowledge and acceptability among pregnant women in Italy. Hum Vaccin Immunother 2018;14:1573–9.

[20] Napolitano F, D'Alessandro A, Angelillo IF. Investigating Italian parents' vaccine hesitancy: a cross-sectional survey. Hum Vaccin Immunother 2018;14:1558–65.

[21] Napolitano F, Navaro M, Vezzosi L, Santagati G, Angelillo IF. Primary care pediatricians' attitudes and practice towards HPV vaccination: a nationwide survey in Italy. PLoS ONE 2018;13:e0194920.

[22] Napolitano F, Napolitano P, Liguori G, Angelillo IF. Human papillomavirus infection and vaccination: knowledge and attitudes among young males in Italy. Hum Vaccin Immunother 2016;12:1504–10.

[23] Betsch C, Wicker S. Personal attitudes and misconceptions, not official recommendations guide occupational physicians' vaccination decisions. Vaccine 2014;32:4478–84.

[24] Napolitano F, Napolitano P, Angelillo IF. Seasonal influenza vaccination in pregnant women: knowledge, attitudes, and behaviors in Italy. BMC Infect Dis 2017;17:48.

[25] Jiang C, Whitmore-Sisco L, Gaur AH, Adderson EE. Tdap Working Group. A quality improvement initiative to increase Tdap (tetanus, diphtheria, acellular pertussis) vaccination coverage among direct health care providers at a children's hospital. Vaccine. 2018;36:214–9.

[26] Rashid H, Yin JK, Ward K, King C, Seale H, Booy R. Assessing interventions to improve influenza vaccine uptake among health care workers. Health Aff 2016;35:284–92.

[27] Hollmeyer H, Hayden F, Mounts A, Buchholz U. Review: interventions to increase influenza vaccination among healthcare workers in hospitals. Influenza Other Respir Viruses 2013;7:604–21.

[28] Mytton OT, O'Moore EM, Sparkers T, Baxi R, Abid M. Knowledge, attitudes and beliefs of health workers towards influenza vaccination. Occup Med 2013;63:189–95.

[29] Tuckerman JL, Collins JE, Marshall HS. Factors affecting uptake of recommended immunizations among health care workers in South Australia. Hum Vaccin Immunother 2015;11:704–12.

[30] Maltezou HC, Katerelos P, Poufta S, Pavli A, Maragos A, Theodoridou M. Attitudes toward mandatory occupational vaccinations and vaccination coverage against vaccine-preventable diseases of health care workers in primary health care centers. Am J Infect Control 2013;41:66–70.

[31] O'Halloran AC, Lu PJ, Meyer SA, Williams WW, Schumacher PK, Sussell AL, et al. Tdap vaccination among healthcare personnel-21 States, 2013. Am J Prev Med 2018;54:119–23.

[32] Boey L, Bral C, Roelants M, De Schryver A, Godderis L, Hoppenbrouwers K, et al. Attitudes, believes, determinants and organisational barriers behind the low seasonal influenza vaccination uptake in healthcare workers - a cross-sectional survey. Vaccine 2018;36:3351–8.

[33] Awali RA, Samuel PS, Marwaha B, Ahmad N, Gupta P, Kumar V, et al. Understanding health care personnel's attitudes toward mandatory influenza vaccination. Am J Infect Control 2014;42:649–52.

[34] Loulergue P, Kernéis S, Stern JB, Kassis-Chikani N, Derradji O, Escaut L, et al. Intention to vaccinate against influenza among health care workers caring for immunocompromised patients. Am J Infect Control 2016;44:1080–2.

[35] Bianco A, Pileggi C, Iozzo F, Nobile CGA, Pavia M. Vaccination against Human Papilloma Virus infection in male adolescents: knowledge, attitudes, and acceptability among parents in Italy. Hum Vaccin Immunother 2014;10:2536–42.

[36] Jaiyeoba O, Villers M, Soper DE, Korte J, Salgado CD. Association between health care workers' knowledge of influenza vaccine and vaccine uptake. Am J Infect Control 2014;42:69–70.

[37] Martinello RA, Jones L. Correlation between healthcare workers' knowledge of influenza vaccine and vaccine receipt. Infect Control Hosp Epidemiol 2003;24:845–7.

[38] Bianco A, Coscarelli P, Nobile CG, Pileggi C, Pavia M. The reduction of risk in central line-associated bloodstream infections: knowledge, attitudes, and evidence-based practices in health care workers. Am J Infect Control 2013;41:107–12.

[39] Bianco A, Bova F, Nobile C, Pileggi C, Pavia M. Healthcare workers and prevention of hepatitis C virus transmission: knowledge, attitudes, and evidence-based practices in hemodialysis units in Italy. BMC Infect Dis 2013;13:76.